POWER

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Man's Dependence on Power

IN order that men may live, work must be done, food must be caught or raised, clothing must be made, shelter provided and distribution carried on.

Before the curse, "In the sweat of thy face shalt thou eat," was uttered, our ancestors could live upon wild fruits, wear fig leaves, sleep under trees and have plenty of leisure, but if the average man wants a modern home with all the conveniences and means of comfort and culture, conventional attire and food from the four corners of the earth, there must be a lot more work done to support the race upon that plane.

If we were dependent upon manual effort, many of the comforts and enjoyments now held cheap by their very commonness would be the perquisites of kings.

The hewer of wood and the drawer of water has been supplanted by a mechanical coal supply and a pumping station which supplies a whole city.

In 1899 2.14 mechanical horsepower were employed for every wage earner in the manufactures of this country. It is now over 3.5 horsepower per wage earner.

The use of this power enables the race to live upon a given scale with so much less effort or with the same amount of application and effort to live so much better.

The conversion of the energy stored in fuel to useful power is one of the most important activities of modern man. It is the industry creative and preservative of industries, the basic industry of them all. To this work the power-plant engineer is devoted, and to him in this work it is *Power's* dearest desire to be helpful.

Riverside Station Enlarged by 50,000 Kilowatts

THE Minneapolis Division of the Northern States Power Co., one of the Byllesby interests, now serves forty-nine communities within a radius of forty miles from Minneapolis. Four hydro-electric generating stations—one at St. Croix Falls, one at Coon Rapids on the Mississippi River, one at St. Anthony Falls in the heart of the city and another at Wissota on the Chippewa River—having an aggregate capacity of 65,000 kw., supply energy to the limits of the water supply. The load has grown so rapidly, however, that it has been necessary to enlarge the Riverside Station, the big stand-by steam plant which has been tied in with the water power and a smaller steam plant in St. Paul. During recent years it has been necessary to operate this steam station almost continuously and finally to add 50,000 kw. to its generating capacity. With 27,000 kw. in three units already installed, the addition will give a total capacity of 77,000 kw.

When the Riverside Station was built in 1911, it was equipped with two 6,000-kw. turbo-generating units. In 1915 a 15,000-kw. machine was added, and in 1919 the station was enlarged to its present dimensions of 294 x 104 ft. to receive two 25,000-kw. turbo-generators and the necessary complement of boilers. The first of these two units is now in operation, and the second will be ready by the fall of 1921. Fig. 3 shows the layout of the entire plant, including all equipment, new and old, and the space for the future unit.

Two 25,000-kw. turbo-generators increase capacity of big Minneapolis stand-by station to 77,000 kw. Features of the new addition are convenient coal and ash-handling, skylight illumination of boiler and turbine rooms, all steel turbine foundations and truck-type oil switches to facilitate their exchange or removal for inspection or repairs.

In the older section of the plant there are twelve 600-hp. boilers served by underfeed stokers. In the new addition there are now five, and eventually there will be ten, cross-drum boilers equipped with underfeed stokers, each rated at 1,360 hp. While arranged on the unit plan, five boilers per turbine, there will be cross-connection between the units and with the older part of the station. The provision of 6,800 boiler horsepower for 25,000 kw. of generating capacity, or 1 boiler horsepower to 3⅜-kw. is considered more than ample. As a matter of fact four of the boilers have carried the load handily, leaving one boiler in reserve to supply steam more economically to the older equipment or to permit cleaning or repairs.

For the new boilers a maximum pressure of 235 lb. is allowed, but the average in operation will be somewhat less. The intention is to supply steam to the turbine at a temperature of approximately 600 deg., made up from 200 lb. pressure and 200 deg. of superheat. From the specifications each of the big boilers is capable of supplying a maximum of 122,400 lb. of steam per hour, meaning operation at 300 per cent of rating, which reduces to 9 lb. per square foot of steam-making surface. The stokers are of the inclined underfeed type with fourteen retorts, driven by either one of two 12.5-hp. variable-speed motors, placed one at either side of the stoker. Each stoker is credited with a capacity to burn 19,600 lb. of coal an hour, which would require an evaporation of 6¼ lb. of water per pound of coal to give the steam-generating capacity previously quoted. Individual turbine-driven fans supply the draft for the stokers.

Draft from the boilers is supplied by self-supporting steel stacks, resting on a steel framework tied in with the building steel and with the overhead bunker support. The final plan is to have one stack, 250 ft. high and 15 ft. 6 in. in diameter, for every three of the big boilers. This diameter at the top gives an area of 188.69 sq.ft., which reduces to 0.046 sq.ft. of stack cross-section per boiler horsepower served, or 1 sq.ft. of stack per 312 lb. of coal-burning capacity. Only two stacks of these proportions have been erected, but two more will be placed when needed. The present stacks are firebrick lined for 51 ft. and concrete lined the rest of the way. Reference to the sectional view of the plant, Fig. 3, will show the boilers arranged on either side of a central firing aisle topped by the bunkers and over all a skylight furnishing illumination for the upper conveyor runs, and at regular intervals between the bunkers, light for the boiler room. An abundance of daylight for operating purposes is secured in this way and a similar plan has been followed in the turbine room.

In the plan view and sectional elevation of the station the general layout of the steam piping will be evident. The pressure and superheat employed call for extra-heavy piping with Cranelap flanges, cast-steel valves, fittings and manifolds, the piping system as a whole being designed for 250 lb. pressure. The sectionalizing valve on the header and the admission valve to the turbine are motor operated. The boilers deliver individually to a 14-in. header continued from the older section of the plant. Long-radius bends have been employed generally, and the construction throughout follows the latest dictates of good practice.

Coal for the station is received by rail and transferred either into yard storage by a locomotive crane or into a track hopper under a train shed running lengthwise with the boiler room. If the cars are of the bottom-dump variety, the coal is dropped directly into the hopper; if they are of the gondola type, the transfer is made by a four-motor traveling crane having a bucket of 1½ cu.yd. capacity.

It will be noticed in Fig. 3 that the track hopper is extended through the building wall, providing a chute, covered with a hinged door, for receiving coal from the outside. This coal may be transferred directly from

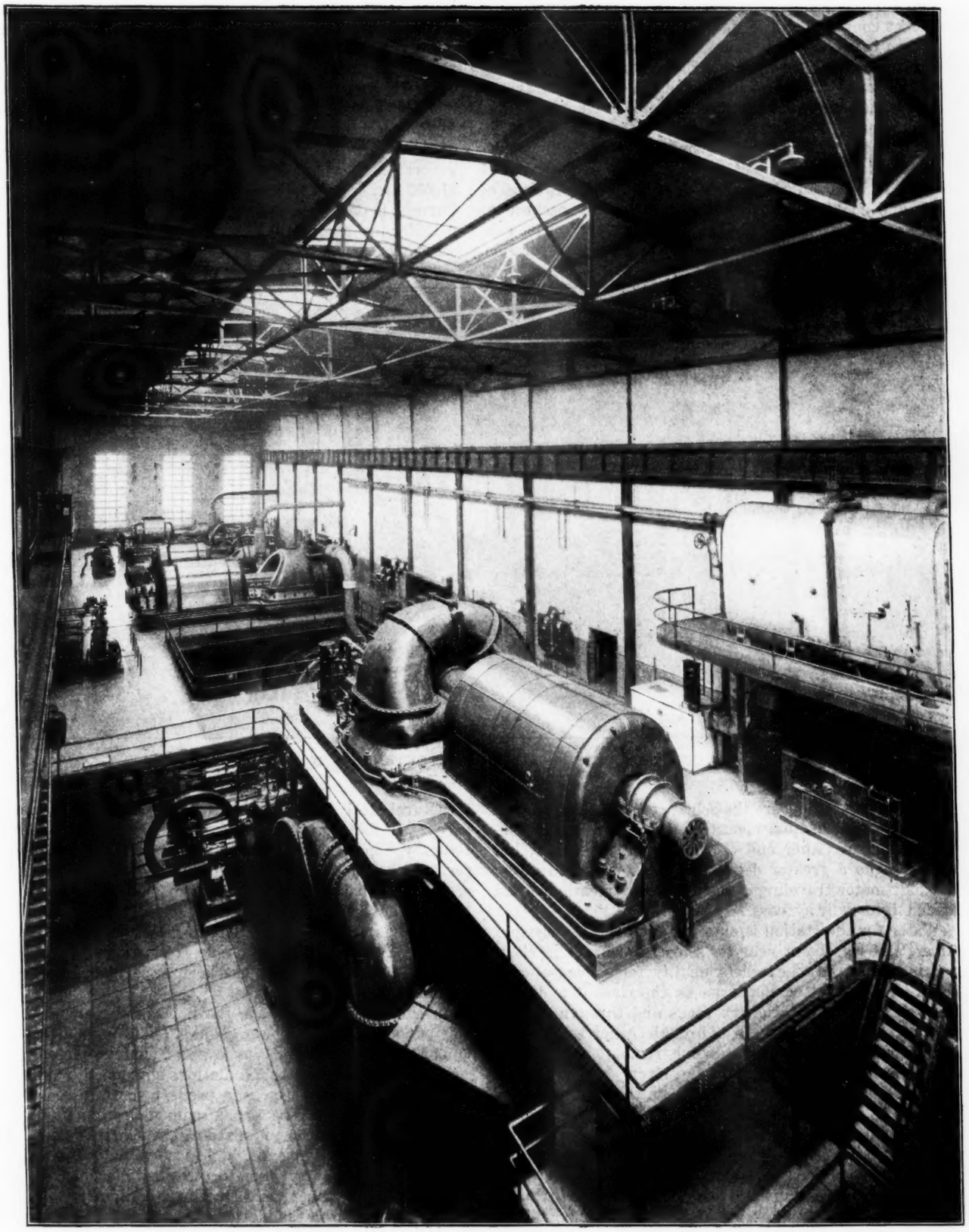


FIG. 1. FIRST OF THE TWO UNITS FOR RIVERSIDE STATION IN FOREGROUND

This turbine is of the horizontal Curtis type and operates at 1,800 r.p.m. The generator is rated at 31,250 kva., or 25,000 kw. at 80 per cent power factor. The foundation is of structural steel, concrete being employed only as footings for the supporting columns.

storage or from cars on the nearest track, by means of the locomotive crane.

From the track hopper the coal is carried by a pan conveyor to the crusher, is delivered to a continuous bucket conveyor and is finally transferred to either one of two belt conveyors running over the individual steel bunkers serving the boilers. Each bunker has a capacity of 175 tons. The capacity of the coal-conveying system approximates 80 tons per hour. Motor drive is employed throughout. From the bunkers the coal is chuted directly to the stokers as no automatic coal-weighing scales are provided.

As is usual in the latest plants, the conveyance of ash and coal has been separated, primarily because of the destructive qualities of the former. The ash-removal system has been made as simple as possible.

For auxiliary drive a careful selection has been made between motors and turbines, so that an approximate heat balance may be maintained. For example, the boiler-feed, service and hotwell pumps, as well as the forced-draft fans, are turbine-driven; the condenser-circulating pump, stokers and coal-conveying equipment are motor operated.

In the generating room the first of the large turbines has been in operation for nearly a year, and the erection of the second machine will soon begin. The turbine is of the horizontal impulse type, making 1,800 r.p.m. The generator is a three-phase 60-cycle machine rated at 31,250-kva., or 25,000 kw. at 80 per cent power factor. Current is delivered at 13,200 volts.

Following a practice that has been common with the company for some time, the big machine rests on a

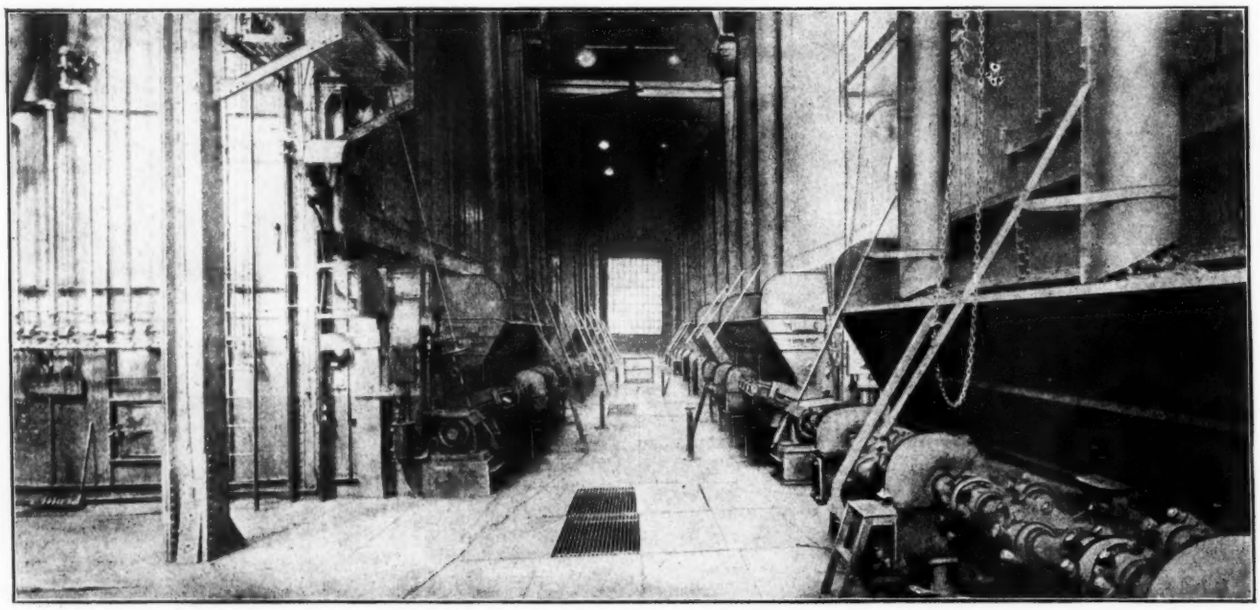


FIG. 2. CENTRAL FIRING AISLE IN NEW EXTENSION TO BOILER ROOM

From the stoker hoppers the ash is received in industrial cars which, by manual operation, are dumped into ash-pits placed at either end of the coal-track hopper, but excavated to a greater depth. The ash is picked up by the four-motor traveling crane previously mentioned and loaded into railway cars.

Water for the station is obtained from the Mississippi River. At this point near its source the water is clean and is considered of excellent quality for condenser and boiler use. At the screen house on the river it is drawn through the usual stationary racks and through motor-driven revolving screens. Through concrete tunnels it is circulated under the turbine room to supply the condensers and is returned to the river.

Boiler-makeup water is drawn from the return tunnel or, in case of emergency, from the city mains. It is delivered under float control by turbine-driven service pumps to a three-section open heater of sufficient capacity to serve the five boilers. From the heater the water passes through a V-notch meter to turbine-driven boiler-feed pumps and is forced to the boilers under the control of feed-water regulators and pump governors. Economizers are not employed, but plenty of exhaust steam is available to raise the feed water to 210 degrees.

structural-steel foundation. No concrete is employed except as footings for the supporting columns. The Byllesby Company has used structural-steel foundations for turbines up to 15,000 kw. capacity since 1914 and previous to that time for turbines of smaller sizes since 1910. The big 30,000-kw. unit mounted in a similar manner has been in operation for nearly a year. The company reports that no trouble from undue vibration or from any other source has been experienced in any foundation of this character.

As will be seen in Fig. 5, the horizontal members of the foundation are built-up girders. The main base is supported by six columns made up of channel plate sections, resting on concrete foundations supported by piles. The entire structure has been properly braced and the steel work designed for a maximum deflection of 0.02 in. The weight of the foundation is much less than if concrete had been employed, and more valuable space is left underneath the turbine for the installation of the condenser, air washer and auxiliary equipment. The cost of the all-steel foundation is somewhat less than one of concrete, and in service the results obtained are of equal satisfaction. Within the steel foundation is the two-pass surface condenser serving the turbine. The condenser has a cylindrical shell and is equipped with

47,500 sq.ft. of surface in 1-in. o. d. seamless drawn brass tubes. The tube sheets are of Muntz metal 1¼ in. thick, and the length of the shell between heads is 20 ft. From the figure given previously, it is evident that 1.9 sq.ft. of surface has been provided per kilowatt of generator rating, and going on the basis of 12 lb. of steam per kilowatt-hour, each square foot of surface must condense 6.3 lb. of steam, or at least that portion of it not turned to water before reaching the condenser.

Circulating water is provided by a 42-in. double-suction volute centrifugal pump which is synchronous-motor driven and has a capacity to deliver 447,500 gal. per min. The pump capacity provides one gallon per minute per square foot of condenser surface, or 80 lb. of water to 1 lb. of steam condensed. Condensation is removed by a 6-in. two-stage turbine-driven hotwell pump; the air pump is of the rotative drive vacuum type. Power is generated and practically all distributed from this station at 13,200 volts. The electrical equipment is housed in galleries extending the entire length of the building along the west side. There are three floors in this section, the top and second floors containing the main 13,200-volt buses, which are in duplicate. On the lower floor are 2,300-volt transformers and switching equipment controlling the station light and power, including exciter units, circulating pumps, sump pumps, stokers, coal- and ash-handling equipment, etc.

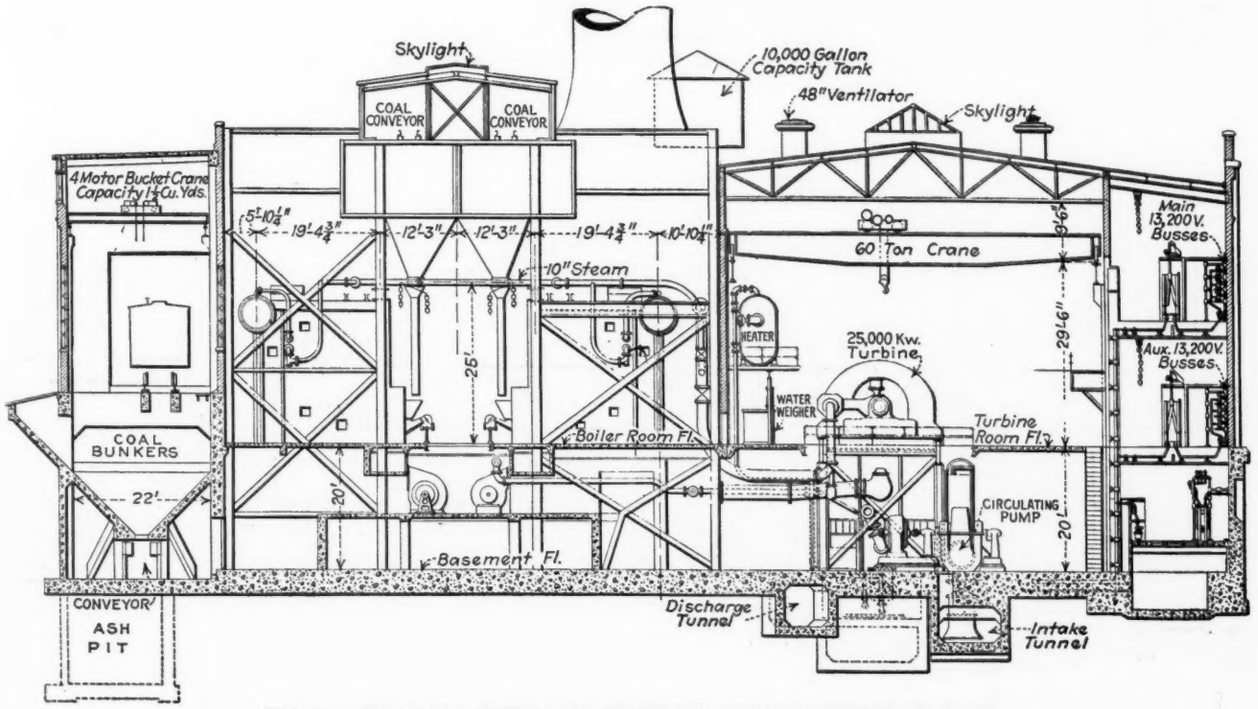


FIG. 3. SECTIONAL ELEVATION THROUGH THE RIVERSIDE STATION

Several of the larger motors driving the station equipment are fed by individual 2,300-volt circuits controlled by separate oil circuit breakers. The smaller motors and the station lighting are supplied through smaller banks of transformers stepping down to 220 volts and 110 volts and grouped in such a manner that there is a substation for the boiler-room equipment and a smaller substation for the turbine-room lighting and small motors. Each of these two groups of transformers is

PRINCIPAL EQUIPMENT OF NEW ADDITION TO RIVERSIDE STATION

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbine	Horizontal-impulse	25,000-kw	Main generating unit	600-deg. steam, 200 lb. press., 200 deg. sup	General Electric Co.
1	Generator	Three-phase, 60-cycle	25,000-kw	Main generating unit	13,200 volts, 1800 r.p.m	General Electric Co.
1	Condenser	Surface, two pass	47,500-sq.ft	Serve generating unit	28-29 in. vacuum	Worthington Pump & Mchry. Corp.
1	Pump	Double-suction volute	42- n., 47,500-g.p.m	Condenser auxiliary	Driven by 400 hp. syn. motor	Worthington Pump & Mchry. Corp.
1	Pump	Two-stage centrifugal	6-n	Condenser auxiliary	Driven by 75-hp. Terry turbine	Worthington Pump & Mchry. Corp.
1	Pump	Rotating dry-vacuum	13x35x30-in	Condenser auxiliary	Two-stage	Laidlaw-Dunn-Gordon Co.
1	Exciter set	Duplex	200-kw	Excitation of gen. unit	Driven by 300-hp. Terry turbine or induction motor	General Electric Co.
2	Screens	Traveling	40,000-g.p.m	Condenser and boiler water	Motor-driven, 10 ft. per min	Chain Belt Co.
5	Boilers	Cross-drum water tube	1,350-hp	Generate steam for new turbine	Max. press., 235 lb., superheat 200 deg	Babcock & Wilcox Co.
5	Stokers	Inclined underfeed	14-retort	Serve boilers	Motor-driven	We tinghohse Elec. Co.
5	Fans	Turbo, conodial	64,000 cu.ft. air per min.	Forced draft	Turbine-driven	Buffalo Forge Co.
5	Superheaters	Fo ter	12,200-sq.ft	Superheat steam		Power Specialty Co.
4	Pumps	Three-stage, dbl. suc.	4-in	Boiler feed	Driven 150-hp. Terry turbine	Worthington Pump & Mchry. Corp.
2	Pumps	Double-suction volute	4-in., 500 g.p.m	Service pumps	Driven by 60-hp. Terry turbine	Worthington Pump & Mchry. Corp.
1	Heater	Three-section open	500,000 lb. per hour	Heat feed water	Exhaust steam, 210 deg	Platt Iron Works
1	Meter	V-notch	500,000 lb. per hour	Meter feed water		Yarnall-Waring Co.
1	Conveyor	Continuous-bucket	80 tons per hr	Elevate coal to bunkers	Motor-driven	Link Belt Co.
1	Crusher	4-roll	80 tons per hr	Crush coal	Motor-driven	Link Belt Co.
2	Conveyors	Belt	24-in	Distribute coal to bunkers	Motor-driven	Robins Conveying Belt Co.
1	Conveyor	Pan	36-in	Coal from track hopper to crusher	Motor-driven	Link Belt Co.
1	Crane	Traveling	60-ton	Serve turbine room	Span, 58 ft	Whiting Fdry. Equipment Co.
1	Crane	Traveling	1¼-cu.yd. bucket	Unload coal	4 motor, span 14 ft	Whiting Fdry. Equipment Co.
1	Stock	Self-supporting steel	250 ft. high. 15 ft. 6 in. diam	Serve boilers	Firebrick and concrete lined	Byllesby design

G.E. switchboard; Crane piping and valves; Edwards blowoff valves; Cranetilt steam traps; Consolidated safety valves; Copes feed-water regulators; Diamond soot blowers; S.F. Bowser oil-filtering system.

fed directly by a separate 2,300-volt three-phase circuit controlled by an individual oil circuit breaker. Induction-type feeder regulators are used to control all station lighting feeders because of the variation of the voltage on the main buses resulting from the station being operated on an extensive distribution and transmission system.

Cutout cabinets containing the main switches and fuses controlling individual lighting and power circuits are located in various parts of the station near the sections to be controlled. All feeders supplying the lighting and the motor-driven station equipment are installed in iron pipe conduits in the most substantial manner to afford maximum protection and continuity of service to the station auxiliaries. The total power demand of electrically operated auxiliaries with all equipment running, when the second 25,000-kw. unit is installed, will approximate 2,500 kilowatts.

The 13,200-volt leads from the generators are made up of copper bars 4 x $\frac{3}{8}$ in., supported on special post-type insulators, with a nominal rating of 25,000 volts. These leads are brought down through a rectangular steel flue from the under side of the generator to the basement floor of the station and carried across under the floor level and up into the lower room of the electrical section above the high-water line, in a rectangular steel flue which is specially designed to be watertight. Above this point the bars are carried along the wall between the turbine room and electrical section to the two floors on which are the main generator oil circuit breakers. Concrete barriers, cast as an integral part of the walls and floors, separate the phases of the generator leads and also all other connections such as feeders, etc., off the main buses.

On the 13,200-volt buses the circuit breakers are of the easily removable truck type, each three-phase breaker being mounted in a steel and asbestos cell, which in turn is mounted on a four-wheel truck running on a track built into the floor. A mezzanine floor is provided over each row of breakers on the second and third floors respectively of the electrical galleries, on which are mounted the oil circuit breaker mechanisms. This floor is in turn supported by a barrier wall between the breakers and the main buses and also by barrier walls between breakers in such a manner that each circuit breaker, in addition to being inclosed in the steel and asbestos built-up truck-type cell, is also further inclosed on three sides and the top by concrete walls. In front of each of these inclosures are permanent heavy wire-screen hinged gates. The use of a traveling hoist on

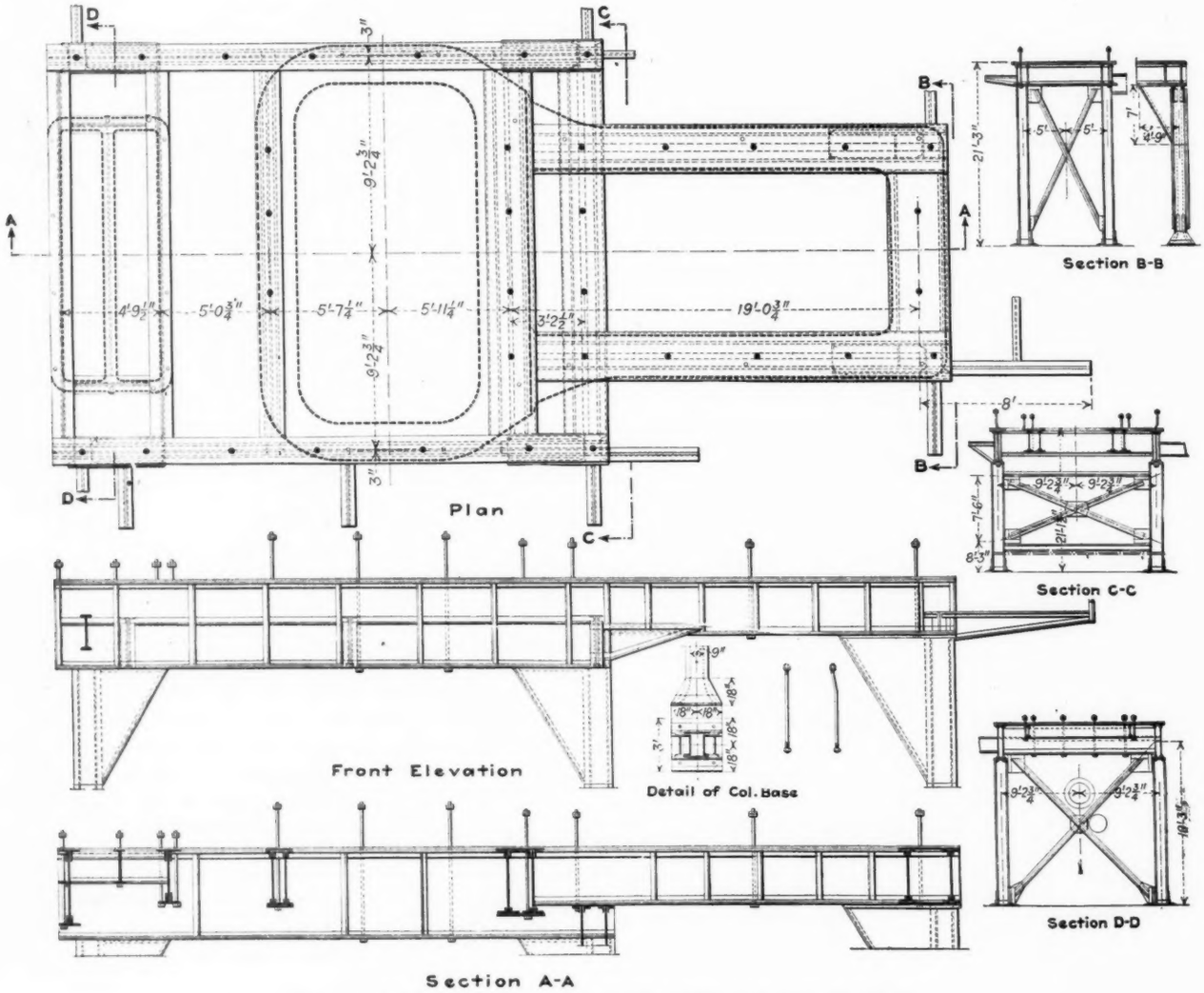
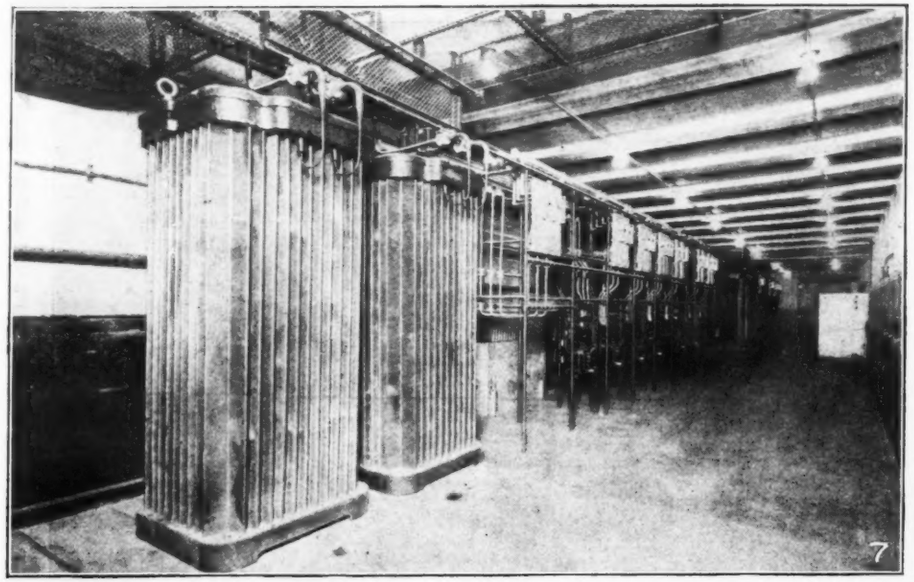
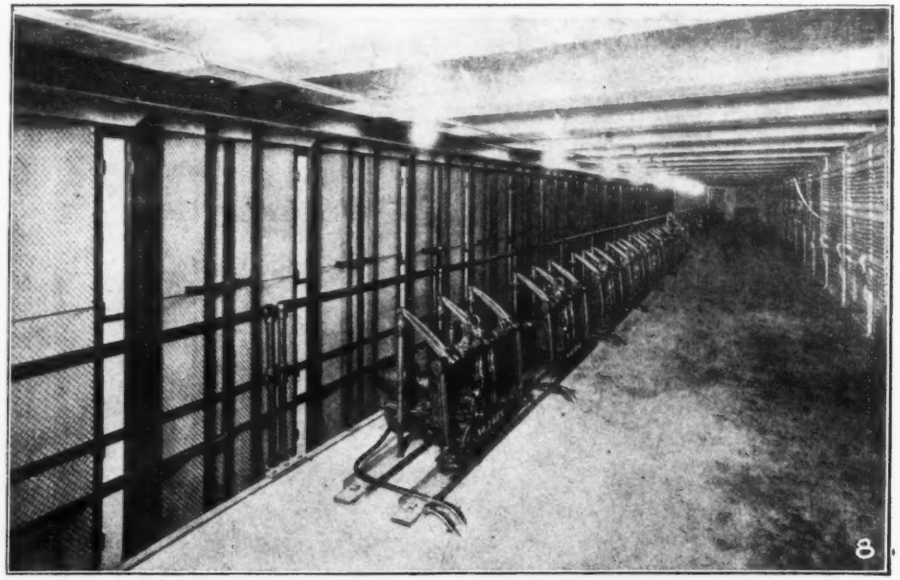
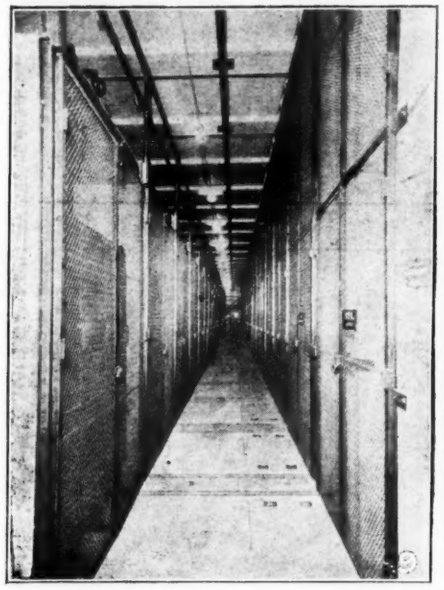


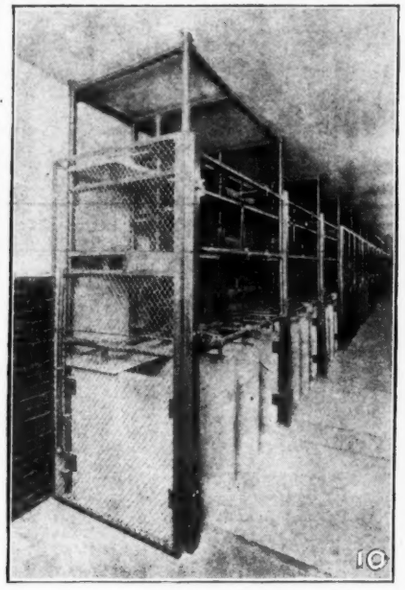
FIG. 4. DETAILS OF STEEL FOUNDATION FOR THE TURBINE

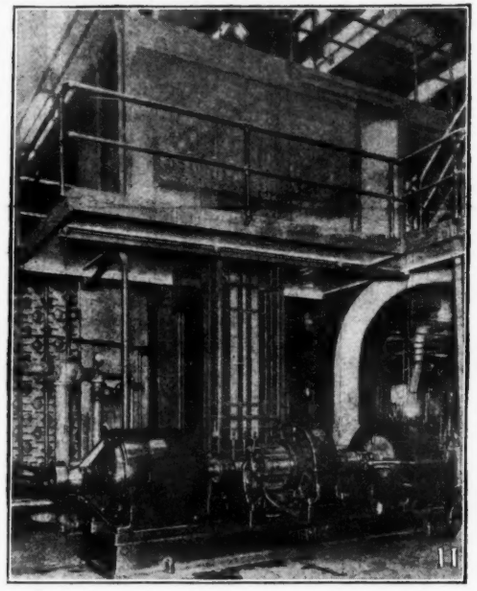
FIGS. 5 AND 6. SWITCHBOARD GALLERY WITH 25,000-KW. UNIT IN BACKGROUND AT LEFT OF UPPER VIEW AND REAR VIEW OF CONTROL BOARD SHOWING WIRING GROUPED IN CONDULETS

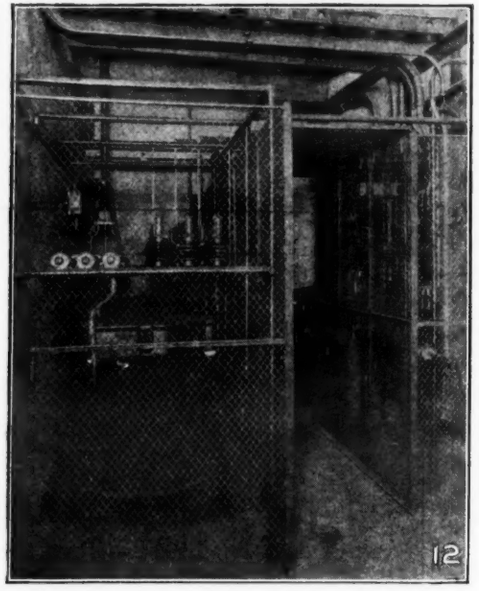












FIGS. 7 TO 12. GENERAL VIEWS OF ELECTRICAL APPARATUS AT THE RIVERSIDE STATION

Fig. 7—Transformers and switching equipment for station auxiliaries. Fig. 8—Oil circuit breaker mechanism on mezzanine floor. Fig. 9—Aisle on main switch gallery with truck-type oil switches at left and generator and feeder connections at right. Fig. 10—13,000-volt bus with protecting screens removed on first three sections. Fig. 11—Three-unit exciter set and connections. Fig. 12—Substation in boiler-room basement serving coal and ash-handling equipment.

each floor, together with a hatchway at the end of the electrical galleries, permits the withdrawal of a breaker in a few minutes' time, and its removal to a convenient point in the station for overhauling or inspection following unusual switching operations.

On the second and third floors the 13,200-volt bus structures are of 2-in. extra-heavy pipe framework. The buses are supported on special post-type insulators having high mechanical as well as electrical strength, and are separated by horizontal barriers of Alberene stone running the entire length of the structure. Permanent hinged heavy wire-screen gates in front of the entire structure afford protection from accidental contact with conductors. Several years' operation of this type of bus structure on the Northern States Power Co.'s system has demonstrated its sturdiness and freedom from interrupted service.

The location of disconnecting switches, the installation of screens in front of circuit breakers, buses, etc., the design and location of floor slabs and other protective features are in accordance with the safety rules adopted and put into operation by the company during the last two years. The arrangement of the entire station in fact has been worked out with a view to making it necessary for the operators to follow these rules.

Outgoing feeders are carried from the circuit breakers in a manner similar to the generator leads, and at a point in the basement well above the high-water mark the copper bars are joined to lead-covered cables which are run to a large cableway below the electrical section, permitting the cables to be taken in any direction to the various duct lines leading from the plant. Disconnecting switches are provided just ahead of the cable potheads, insuring safety to station operators and to men working on the underground cables. Potential transformers are placed in separate compartments and are arranged to be disconnected in such a way that station operators or construction men are amply protected. Provision is made for a double set of synchronizing buses on the switchboard, and also for synchronizing any generator in the plant with any incoming feeder.

A three-unit steam-turbine and motor-driven exciter set is operated in conjunction with the first 25,000-kw. turbine, and a duplicate set is to be installed with the second unit of the same capacity. The control equipment for the exciter is close to the unit itself, and likewise close to the main generator, with resulting short exciter connections. Generator and exciter rheostat controls, remote control exciter circuit breakers, etc., are on a gallery halfway between the basement floor and the main operating floor of the turbine room, and inclosed by a wire-glass partition for protection.

From the illustrations it will be evident that the electrical section of the building, containing the 13,200-volt switching equipment, is entirely separated from the turbine room and is provided with special ventilation so that there is practically no condensation even at the subzero temperatures prevailing in Minneapolis throughout the greater part of the winter. Heat for this section is supplied by steam radiators in the basement, and a penthouse on the roof carries out the heated, foul air. A motor-driven fan, located in the penthouse, provides additional ventilation for emergencies. It is capable of changing the air in the entire electrical section every two minutes and can be started from any one of seven stations scattered throughout the electrical galleries.

type oil switches at left and generator connections. Fig. 12—Substation in boiler-room basement serving coal and ash-handling equipment.

Some Recollections of Francis Stevens

By W. D. Forbes

When the Hoboken ferryboat "Hamburg" was undergoing a trial trip, Professor Denton, of Stevens, had a number of his young men taking indicator cards and other data, and on the upper deck three young engineers were at work taking temperatures of the stack and investigating the gases. Along came Francis Stevens, then over 80, but active and interested in all that was going on. He came up to the stack and after watching the work for a time, said: "Very necessary work, young men, very, very; but it is not always convenient to go into the matter so carefully, and a very practical way to determine whether or not the stack is carrying off too much heat is to see if the paint sticks on it." When Mr. Stevens had moved away, one of the young men remarked, "I guess that is a good practical point to remember;" and so it was.

Mr. Stevens was quite absent-minded at times, as he would get entirely wrapped up in his thoughts. I had known him all my life and my family was known to him. He sent for me one day and asked if I would go to various places and estimate the amount of coal there stored. I said I would, and he sat down to write me a pass over the Pennsylvania road. As he was making out the pass, he looked up and asked, "How is your mother, Will?" "Quite well," I answered. When I took the train, I handed the pass to the conductor, who was an oldish man. He looked at it and began to laugh, then handing it back to me said: "Frank need not have signed that. I would have known who gave it to you without that. Just look." There, written in under my name was, "How is your mother, Will?"

Mr. Stevens told me that he was, he thought, the first marine man to use blueprints, and he saw this valuable process first at the works of R. Hoe & Co., New York, about 1876.

Mr. Stevens was made a Ph.D. by Stevens Institute a few years before he died, and he was vastly proud of the honor.

Diesel Engine Pointers

In starting a Diesel, do not overprime the fuel valves. Connecting rods have been bent by fuel oil entering the starting cylinders in large quantities and igniting before top center.

Extreme care should be used in grinding fuel-pump valves. A hair-line score will destroy the pump's action. Clean the fuel pump twice a year and at all times use a filter in the oil lines. Even the highest grades of fuel oil will carry grit and small particles which will lodge in the pump and fuel valve.

Understand the action of the engine governor and fuel pump.

If a vertical Diesel engine has the habit of cutting the teeth on the camshaft gear drive, try a heavy gear compound. Also keep the gear bearings free from excessive play.

Do not allow the air discharge from the air compressor to go higher than 200 deg. F. If carried too high, oil deposits in the air line may ignite.

It is very necessary to keep the air lines drained. If the starting and injection bottles are charged before daylight, the moisture in the air is greater at this hour. This water will settle in the air bottles and lines and must be blown out.

A National System for the Inspection and Registration of Steam Boilers

SOME weeks ago the writer called upon George Uhler, Supervising Inspector General of Steam Vessels. He was accompanied on the visit by a man, since become well known, who started life as a marine engineer. After the old days had been gone over and the fate of old ships and shipmates discussed, my fellow caller asked if it was possible to see his record. The attendant who answered the push button reappeared in a few moments with an index card bearing the whole story: John A. Stevens, 1889, by whom examined and where, grade of license, steamers that he had served on and his record up to the last renewal.

Mr. Uhler then called for other cards and showed the test records of the material that had gone into the boilers of certain ships. They told not only of which boiler it had become a part, but into which part of that boiler it went. There was a record there of each boiler of every vessel under his supervision, who made it, what it was made of and what pressure it was allowed to carry.

The explosion of a boiler on shipboard is a comparatively rare occurrence. They are required to be up to the board's standard and are subjected to periodical inspection. There is no such general system for land boilers. About one-third of the states and a few of the larger cities have inspection service of varying sorts. The Hartford Steam Boiler Inspection and Insurance Co. published in the October issue of its *Locomotive* a summary of the explosions, of which it has been able to obtain records, in the past forty years. The total number of explosions covered is 14,281 (almost one a day on an average, Sundays and all) in which 10,638 lives were lost and 17,085 persons injured, all of these in the United States. No estimate is given of the property damage. Although the plotted curves show a marked falling off in the frequency of explosions, notwithstanding the greater number of boilers in use, it is a fact that there are still recorded in the public prints more than one explosion per day on an average in the United States alone, and that such accidents greatly exceed in frequency in this country those in the countries of Europe where governmental supervision is general.

The Problem

Under our form of Government there can be no Federal inspection law dealing with boilers other than those used in interstate commerce. Marine boilers in interstate or ocean navigation are now under the supervision of the Board of Supervising Inspectors of the Department of Commerce. Locomotives used in interstate commerce are inspected by the Interstate Commerce Commission. But boilers used for industrial or other purposes within any state are subject to legislative control only by that state, and any attempt of the Federal Government to specify the materials of which they must be made, the features of their design, the nature of their fittings and accessories, the pressures which they may carry and other conditions of their installation and operation would be an infraction of states' rights.

And yet it is desirable for many reasons that practice should be uniform; that, in view of the impossibility of having one Federal law, the laws and practices of the various states and municipalities which provide for inspection and supervision of steam boilers should be framed after one model and mutually interworkable. Some of these reasons are:

If every state and those municipalities which deal locally with the question should have a different standard to which a boiler must be built, the boiler manufacturer would be placed in a most embarrassing position.

He could not take an order for a boiler without knowing into what state or city it was going.

In the absence of enough definite orders to keep his shop running at capacity, he could not build boilers for stock and thus keep his men at work and his oraginzation intact, but would have to lay off all except those engaged upon boilers actually ordered.

The consequences would be unsteady employment for boilermakers and a lowering of the efficiency of the craft.

The absence of stock boilers would be an embarrassment and expense to the purchaser in the impossibility of quick delivery and the increasing price of the made-to-order product.

The design department of every boiler shop would have to include somebody who was thoroughly conversant with the requirements of each state and municipality in their minutest detail, and there would always be the risk of having an expensive piece of work rejected through failure to comply with some requirement of a local regulation, subject to frequent change and to varying interpretation by a changing personnel.

The boiler manufacturer would have to keep on hand an infinite variety of stock and fittings to meet the various requirements of different inspection departments.

A contractor using portable boilers, having finished a job in one city or state, might find that the boilers built to the requirements of that political division were totally unacceptable to the inspector of the city or state in which he wished to use them next.

The owner of a stationary boiler, wishing to sell it, might find his possible purchasers limited to those in the state or city for use in which the boiler was built.

Perhaps enough has been said to establish the desirability of uniformity in the requirements as to what a boiler should be, and to prove that there should be a standard for boiler construction, a boiler built to which standard should be universally acceptable.

Interstate Inspection

Supposing there were such a universally acceptable standard available, how should it be known that a boiler had been built to it? A state boiler inspector can have the boilers built in his own state inspected during construction by his own inspectors, but how is he to know that a boiler built in a distant state has been built according to the standard?

The solution that suggests itself is that the inspector of the state or city into which the boiler is going may accept the certificate of an inspector in the city or state in which the boiler is made, that the boiler has been built in accordance with the standard; but in order that he may with confidence transfer to an unknown inspector a part of the responsibility with which he has been charged, he must have some assurance that the inspector is competent and trustworthy and not one who has received his appointment for political or other considerations instead of through qualification for the job. There must be some kind of an understanding between the chiefs of inspection departments that the services of their subordinates shall be acceptably interchangeable. The subordinate inspectors should pass a test of which accurate record is kept, and this test should be one that would qualify them in the eyes of the chiefs of departments of all of the states.

Inspection by Insurance Companies

Boilers are not only inspected during construction but visited periodically after they have been put into use. There is usually an annual internal inspection and a quarterly external examination. The majority of power boilers used in industrial pursuits of any magnitude are insured and subject to the inspection of the insurance companies. Because of financial considerations the investigations by the insurance inspectors are designed to search out every defect or weakness, and if these inspections are made in a way that the state inspector can approve of, there is no use of another inspection by the state. The solution is to make the insurance inspector a quasi state official and to have him file a report of his inspections with the state inspector just as do the subordinate inspectors of the state, who confine their inspections to boilers not subject to insurance inspection. This involves the acceptability of the insurance inspector to the state inspector and his subjection to the same sort of an examination or test as is proposed in the preceding paragraph.

Existing Substandard Boilers

While a standard of excellence might be set to which boilers in future shall be built, there are in service hundreds of thousands of dollars worth of boilers which would not accord with this standard in all particulars. In such particulars as the number, capacity and connections of safety valves, the use of fusible plugs, the pipings of their water and pressure gages, they could be brought up to the standard of safety with little expense and inconvenience. In many cases, however, existing boilers depart in material, design and construction from what, in present expert opinion, constitutes safe practice. To peremptorily order them out of service would be confiscatory and unnecessary. Under the watchful care of experts who know their weaknesses and where to look for the first manifestations of trouble, they can be allowed to fill out their term of usefulness with a reduction, as its necessity may develop, in the severity of their service, and a gradual retirement. The process will require a great deal of tact and skillful application on the part of the inspector, weighing the probability of explosion against the cost of renewal, and applying the best processes of his craft to the detection of incipient failure in order that the boilers may be useful until they become a real menace. This is not only a local, but an individual problem. It should be left in the hands of the local inspector, with an attempt at only so much uniformity of practice as is compatible with different local conditions; but there should be an organization or machinery whereby the experience of each department or inspector shall be made a part of the collective experience, and the causes and manner of failure be studied and information promulgated for the guidance of the entire inspector body.

A consciousness that this would be painstakingly and intelligently done in a kindly and co-operative spirit and that their old boilers would be kept in use under expert supervision so long as they were safely serviceable would win for boiler legislation the approval and support of many boiler users who now oppose it as unwarranted interference.

New Substandard Boilers

The problem of the existing boilers which are below standard will solve itself. They will work themselves out in a generation. There are those, however, who insist upon making and using boilers that do not conply with the requirements of safety as defined by accepted authorities. The claim is made that for the service to which such boilers are put—oil country, lumbermen's, contractors' and agricultural uses—the extra cost of the safer boiler is not warranted. The makers and users of such boilers have enough influence to delay the provision for boiler inspection by some of the states, and in some states in which such legislation is adopted, to get themselves exempted from its provisions. This condition will work itself out in time. If these cheap boilers do not explode from inherent faults, it will be apparent that they have been treated with unwarranted severity. If, however, the caution of the experts is justified, and boilers explode because of practices the danger of which has been publicly and repeatedly pointed out, any court will find their explosion to be due to gross negligence and the damages and opprobrium will be found more onerous than the small additional cost of the safe standard boiler.

A System of Records

A not inconsiderable feature of the problem is the need of a uniform system of recording the origin, age, location, type and capacity of every boiler in the country and of investigating, reporting and recording major and minor explosions, to the end that all boilers may be known to the inspection department and properly supervised, the most prolific causes of explosions may be determined and avoided and that there may be available complete and correct statistics of the number of accidents and damage incurred, and the proportion which the number of failures bears to the number of boilers in use. At the present time nobody knows within 50 per cent how many boilers there are in use in the United States, what their capacity is and how many are added and scrapped annually.

A Trained Inspection Corps

Another need is to provide a corps of expert inspectors who know the requirements of the safe boiler in all of their details, who are competent to compute the efficiency of riveted joints, the sufficiency of bracing and to determine the pressure that may be safely carried by a given boiler; who know shop methods and materials and are capable of seeing that, in material and workmanship, a boiler is up to standard; who can get into a boiler which has been in use and by the

sound and feel of the testing hammer and by the visible indications of pitting, grooving and corrosion, by minute leaks, distortions and signs of local distress, detect incipient trouble and forestall accident. Such service demands adaptability, training and experience and offers an opportunity for the exercise of real genius. The system should not only provide that the individual inspector should be of a high order of capability, but should arrange for such interchange of thought and experience that there may be available to each inspector the collective experience and knowledge of the craft.

The Solution

There should first be available a recorded set of standard requirements with which a boiler should comply to be structurally safe. This standard should not be unreasonably high, requiring superlative materials, difficult to procure, and processes and methods of manufacture impracticable for the ordinary boiler shop; but it should insist upon materials adapted for the purpose, upon stresses well within the capacity of those materials to carry, upon the sufficiency and dependability of accessories and fittings, upon honest workmanship and upon the avoidance of shop practices which impair the integrity of the material and of features of design which have been found to be provocative of failure.

Such a standard is ready to hand in the Boiler Code of the American Society of Mechanical Engineers, formulated by a committee composed of representatives of the users, designers and manufacturers of boilers and boiler materials after numerous and exhaustive hearings in which the representatives of every interest affected took part. The committee was instituted and is supported by the American Society of Mechanical Engineers, the leading professional society in this branch of engineering, with no other aim or motive than public and professional service, and it is difficult to conceive how there could be procured a code better adapted to the purpose in hand, prepared by a more impartial or better qualified body of men or sponsored by an authority more likely to inspire public confidence. This committee is a continuous body with an office and permanent secretary at the headquarters of the society in New York and holds monthly meetings for interpreting the Code and considering the revisions which practice under it seems to make advisable.

The A. S. M. E. Code has been adopted more or less completely as their standard for new construction by the boiler-inspection departments of seventeen states. Massachusetts has its own rules, which so far as new construction is concerned, differ from the Code in only a few particulars. The other states have as yet no boiler-inspection departments, but many cities have ordinances providing for the inspection of boilers, and eleven of them have adopted the A. S. M. E. Code as their standard.

A national board composed of the responsible heads of these different inspection departments would furnish the ideal medium for solving the rest of the problem. Through association and discussion these men could unify their ideas as to the application of the Code in their requirement as to new boilers; could standardize, so far as practicable in accordance with local laws and conditions, their treatment of existing installations; could advise the Boiler Code Committee of inadequacies and inconsistencies found in the Code by their use of it and consult with them as to its revision; could compare and combine their records, determine the most prolific causes of boiler explosions and the best means of preventing them, and set a standard of qualifications for inspections which would make the certification of a boiler by one of them acceptable to all the rest. The convention of such a board could well become the assembling point of the best information upon boiler construction, failure and inspection in the world, and this information, when impressed upon their subordinates by the department heads composing the board, would result in an organization of the best experts that could be produced, whose intelligent oversight of the boilers of the country would result in the annual saving of thousands of dollars and hundreds of lives. The knowledge that their chief inspectors would sit in such a national convention and that their subordinate inspectors would have to pass the scrutiny of such a national board would have a healthy effect upon the appointing power and work for clean and fit members of the local boards of inspection.

The organization chart upon the opposite page is simply suggestive. The Boiler Code is established, has been adopted by seventeen states and eleven municipalities and is gaining prestige and authority with publicity and use. The Boiler Code Committee is a going concern. The National Board of Boiler Inspectors has been organized by a few of the inspectors who were in attendance at one of the meetings of the Boiler Code Committee. A meeting of the board has been called for February 2-4, in Detroit, and special efforts are being made to insure the attendance of a representative from every state and city having a boiler department that has adopted the A. S. M. E. Code. Adoption of the Code was made a requisite for membership by the organizers of the board.

The board comprises representatives of city and county, as well as of state departments. The chart has not been complicated by an attempt to represent them separately. In order that the organization may be 100 per cent effective it must cover all the boilers in use and include all the departments inspecting them. If certain states prefer to divide their service into a number of municipal or local branches, that condition must be accepted and a representative of each department included in order that the entire ground may be covered. The practice of making the insurance inspectors quasi state functionaries and accepting their reports as official is already in vogue. There is as yet no system of interstate certification of inspectors.

The Council of the American Society of Mechanical Engineers has already invited the National Board of Boiler and Pressure Vessel Inspectors to elect one of its members as its representative on the Boiler Code Committee, and the chiefs of all departments are invited to sit with the committee and take part in its deliberations but without vote. There is therefore ample liaison between the Code Committee and the Board. The insurance companies are represented upon the Code Committee, have by law, representatives upon the Boards of Boiler Rules of some of the states, and their inspectors are members of states corps.

All of the elements of such a system are in existence; it remains only for the National Board of Boiler and Pressure Vessel Inspectors to co-ordinate them and put them into practice; and as a suggestion to this end as well as an exposition to the public of the possibilities of such an organization, this presentation is respectfully proffered.

BOILER CODE COMMITTEE *of the* AMERICAN SOCIETY *of* MECHANICAL ENGINEERS

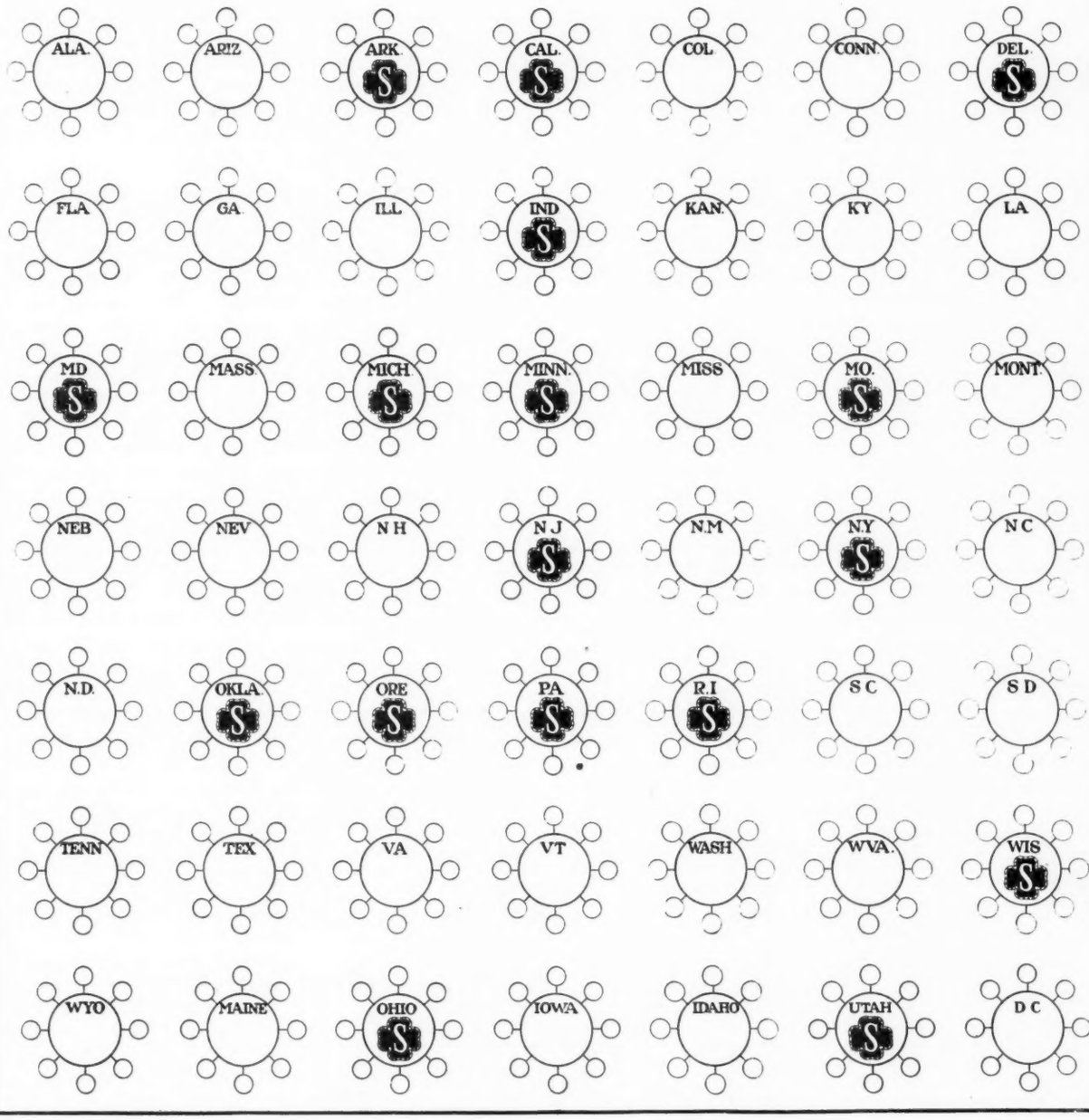
COMPOSED of experts in the design, construction and inspection of boilers and other pressure vessels.
APPOINTED by the Council of the American Society of Mechanical Engineers (One member by the National Board of Boiler Inspectors)
NUMBER Indeterminate, at present 23
FINANCED by the American Society of Mechanical Engineers.
FUNCTIONS (a) To formulate rules and specifications for the design and construction of steam boilers and other pressure vessels. (b) To interpret the Code (c) To revise the Code as the progress of the art shall require or experience in its use suggest
MEETINGS Monthly at the headquarters of the Society, Engineering Societies Bld., 29 West 39th St., New York City

NATIONAL BOARD *of* BOILER INSPECTORS

COMPOSED of the Chief Inspectors or heads of the Boiler Inspection Services of the several states, or cities
APPOINTED by virtue of their office *NUMBER* one for each department represented
FUNCTIONS (a) To determine the most prolific causes of explosions and the best methods of preventing them (b) To formulate a uniform system of recording the origin, age, type, size and location of the boilers and other pressure vessels in their charge and of the casualties occasioned by them, to the end that the statistics of the several states may be comparable and capable of being coordinated

(c) To pass upon the competency and acceptability for interstate service of the inspectors in the several states
(d) To compare methods of dealing with boilers already installed - or which, by virtue of exemptions in the acts creating the departments, are allowed to be installed - which are of a standard of excellence inferior to that prescribed by the Code, to the end that as much uniformity of method in treating such cases may be secured as is compatible with the varying local conditions

(e) To advise the Boiler Code Committee of revisions which their experience in their use of it as a standard indicates would be desirable in the Code
(f) To pass upon the acceptability of specific designs, constructions, accessories, appliances, apparatus and methods
(g) To elect one of their number as a voting member of the Boiler Code Committee
(h) To compare experiences; to discuss methods of boiler inspection, how best to detect incipient failure and to circumvent disaster; to review the causes and methods of notable explosions with a view of learning how they might best have been avoided; to invite and discuss papers upon boiler and pressure-vessel design, construction, operation, inspection and failure from those having special information upon these or other pertinent subjects and to communicate to their subordinates and apply in the work of their departments the collective knowledge of the subject in these various ways made available
(i) To keep statistics of: The number, type and capacity of boilers in use The number, type and capacity installed and scrapped each year The number of major and minor accidents with the number of consequent fatalities, serious personal injuries and property loss and the cause if ascertainable
(j) To decide upon uniform administration of the Code, to the end that manufacturers and purchasers of A.S.M.E. Standard boilers may be assured of their approval and acceptance by the inspection departments of all the states



Allowable Temperature Rise for Motors

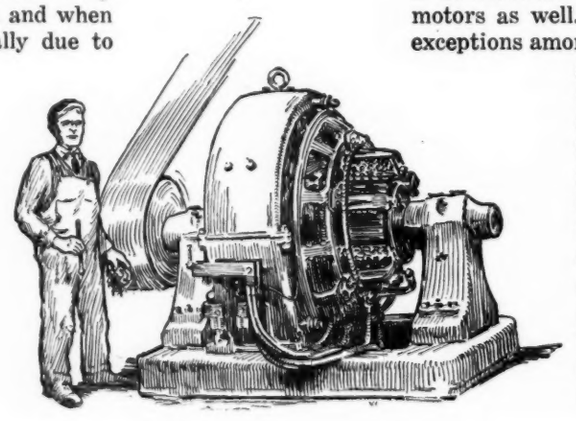
Comparisons Between the Fifty-Degree and Forty-Degree Rise Motors—The Standardization Rules of the A. I. E. E. and the Electric Power Club on Temperature Rise—Two Armatures Having the Same Temperature at Full Load May Have Different Temperatures at Increased Load—Tables Making Comparisons of Insulations When Subjected to Various Temperatures

By H. M. PHILLIPS

IT IS obvious that for a given rated horsepower and speed it is possible to design a motor giving a 50-deg. temperature rise that will be materially lighter and cheaper than a motor of the same horsepower and speed that operates with a 40-deg. rise. Advocates of the 50-deg. motor also claim that for the same service it will be as good as or even better than the 40-deg. motor and that the 50-deg. standard should therefore be adopted in practically all cases. It is stated that these claims are substantiated by a large number of tests conducted by the most eminent engineers and by the behavior of a great many motors under operating conditions. There are a number of points that do not appear to have been covered in the various articles upon this subject that have appeared from time to time in technical publications. Some of these will be touched upon in the following.

What a 50-Degree Motor Is

In speaking of a 50-deg. motor it is understood that its operating temperature after running under full load for the specified time, as measured by thermometers, is 50 deg. C. above that of the surrounding air, which is assumed to be not over 40 deg.; and that the hottest spot in the interior of the windings is 15 deg. higher in temperature than indicated by the exterior thermometers. This gives an actual temperature of 105 deg. C. for the "hot spot" in the interior. In some cases it is said that the life of the insulating materials commonly used in motor construction is in no way affected by continuous operation at 105 deg.; more conservative advocates of the 50-deg. motor claim that the life is "sufficiently long" at that temperature. Advocates of the 40-deg. standard maintain that the 50-deg. motor is short-lived and a trouble maker. In the "Standardization Rules of the American Institute of Electrical Engineers" we find the statement: "There does not appear to be any advantage in operating at lower temperatures than the safe limits, so far as the life of the insulation is concerned. Insulation may break down from various causes, and when breakdowns occur it is not usually due to the temperature at which the insulation has been operated, provided the safe limits have not been exceeded," and "When the safe limits are exceeded, deterioration is rapid." The "safe limit" for ordinary motors may be assumed to be 105 deg. from the fact that it is given as the maximum temperature allowed by the same rules for cotton, silk, paper and similar material "when so treated or impregnated as to increase the thermal limit." A 10-deg. lower limit is specified when the insulating material is neither treated nor impregnated.



If the foregoing rules are to be made the basis for the claims of the 50-deg. motor, it must be assumed that the cotton and paper insulations have been "so treated as to increase their thermal limit," which may be admitted to be possible but may not be the case in practice, especially if the 50-deg. motor becomes the standard for all manufacturers. The application of almost any kind of insulating varnish apparently is considered by some manufacturers to fulfill the requirements, with small regard to the quality of the material or the manner in which it is applied.

Deterioration of the Insulation

As it is admitted that the deterioration of the insulation is rapid at a temperature in excess of 105 deg., the actual hot-spot temperature of the 50-deg. motor is a matter of considerable interest. The temperature of the motor windings is almost invariably taken by thermometers applied to the surface of the coils. The rules of the Electric Power Club state that thermometers shall be used on all motors of less than 200 hp. On the assumption of the American Institute of Electrical Engineers that the temperature of the air surrounding the motor is 40 deg. C. (104 deg. F.) and that the hottest spot is 15 deg. higher than the thermometer reading, the motor with a 50-deg. rise has a hot-spot temperature of 105 deg. The American Institute of Electrical Engineers allows five degrees greater rise when the temperature is obtained by the change in resistance of the motor windings, it being assumed that this method comes within ten degrees of the actual hot-spot temperature. The writer believes that these figures, which are said to be based on a large number of carefully conducted experiments, apply quite closely to the majority of motors exceeding 10-hp. capacity and to a considerable proportion of the smaller motors as well. There are, however, many exceptions among the smaller sizes and some among the large motors. This is amply proved by the fact that the rise of temperature by the resistance method is frequently from ten to twenty degrees higher than that obtained by thermometer measurements, which indicates at least an equal increase in the temperature of the hot spot. Thermometers placed upon the armature seldom attain their maximum

temperature in less than fifteen minutes after cutting off the power, and no correction is made for the cooling of the armature during that period. With a small armature that operates at a high temperature, there must be a material loss of temperature during this period.

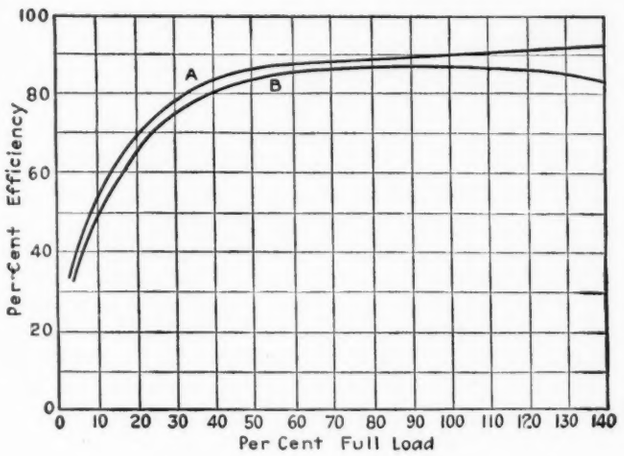
No correction is made for the temperature of the surrounding air, it being assumed that it would be negligible. It is stated that numerous experiments justify this assumption. If a motor is tested with a room temperature of 22 deg. C. (72 deg. F.) and shows a 50-deg. rise, the thermometer reading for the temperature of the winding would be 72 deg. C. and the hot spot 87 deg. The same motor with a room temperature of 40 deg. C. is assumed to give a hot-spot temperature of 105 deg. C. The possibility of error due to the foregoing assumption may be seen from the fact that the resistance of the armature windings and the heat generated in them will be increased by about 6 per cent at the higher temperature; if the motor is series wound, the same will be true of the field windings. The speed of the series motor will also be slightly reduced, which will tend to increase the temperature on account of the lessened ventilation: It is hardly conceivable that the rise in temperature will not be perceptibly increased by these combined factors; and if the motor is, at the time of original test, operating at the safe limit, any increase in temperature rise when operating at higher air temperatures is conceded to cause rapid deterioration.

After the motor has been in operation under service conditions for any considerable period, it is extremely probable that accumulations of dust in the windings and ventilating ducts, even though the motor is blown out with compressed air at regular intervals, will cause a temperature rise slightly above that obtained on test. In addition to this, operation at voltages slightly below normal or a difference in the heating of the commutator due to wear or other causes may increase the armature temperature.

Knowledge of Motor Overload Capacity

The 50-deg. motor must not be allowed to carry an overload. The Standardization Rules of the American Institute of Electrical Engineers state that, "regardless of temperature, loads in excess of the rating should not be taken from a machine." The advocates of the 50-deg. motor state that the ability of the 40-deg. continuous-duty motor to carry a 25 per cent overload for two hours is a relic of our earlier days of ignorance; that the engineer of today knows with a considerable degree of accuracy the maximum load that a given motor will be called upon to carry and can order his 50-deg. motor accordingly. Assuming that the compliment to the engineer's knowledge is deserved, it would seem probable that he would use equal intelligence in ordering a 40-deg. motor and obtain better results. It does not appear good engineering, for instance, to use the same size motor to carry a load of 25 hp. for five minutes during the day or week, and operate at 15 hp. for the remainder of the time as would be used to carry 25 hp. continuously. As a matter of fact, it would be absurd to order even a 50-deg. motor on this basis, as a 20-hp. motor would be quite sure to answer the purpose. The point is that he has more definite knowledge of the load-carrying ability of the 40-deg. motor than he can usually obtain in regard to the 50-deg. machine. If the rule were followed and all motors ordered with a rated capacity equal to their maximum short-time load, the great majority of motors would actually operate at a temperature of 40 deg. or less, the remainder at approximately 50 deg. By intelligent use of the knowledge of the overload capacity of the 40-deg. motor, the operating temperature of all motors would be more nearly uniform, which is certainly better engineering and tends toward economy both in first cost and in operation.

Two armatures, having the same temperature rise at a given load, may show very different temperatures when the load is increased. The principal factors affecting the armature temperature are the energy loss in the copper, energy loss in the iron, radiation from the fields and motor frame, ventilation and, for short-time ratings, the thermal capacity of the armature. In the case of one motor the energy loss in the copper may be comparatively small and the motor efficiency higher on overload than on full load (curve *A* in the figure); as the copper loss is the only factor that changes materially with the load, this motor will show a comparatively slight change in temperature with increase in load. The second motor may have a very high copper loss, with the other factors comparatively small; the motor efficiency is likely to fall off with an increase of load, and (curve *B* in the figure) as the copper loss varies as the square of the current, the temperature will rise rapidly with increase of load. The more information that the purchasing engineer has in regard to the operating characteristics of a motor, the better able is he to judge of its suitability for his work; a definite specification or guarantee in regard to overload is therefore desirable.



MOTOR-EFFICIENCY CURVES

The common practice, covered by the Standardization Rules of the American Institute of Electrical Engineers, of selling 50-deg. motors on a short-time rating, virtually concedes either the necessity of carrying an overload or of operating below the 50-deg. limit. Referring to the rules, we find: "Many machines are operated on a cycle of duty which repeats itself with more or less regularity. For purposes of rating either a continuous or a short-time equivalent load may be selected, which shall simulate, as nearly as possible, the thermal conditions of the actual duty cycle." The words, "simulate as nearly as possible the thermal conditions of the actual duty cycle" are assumed to mean the production of a temperature rise that is as nearly as possible the same that would be obtained in actual service. Taking the case of an ordinary machine tool, a lathe for instance, the actual duty may consist of a heavy load (roughing cut) of 15 min. duration, one minute with

the lathe running light, a moderate load (finishing cut) for 15 min., a series of other light loads and shutdowns while turning up shoulders, changing tools, etc., a 15-min. shutdown while putting in a new piece of work and a repetition of the cycle. The heavy load first mentioned may or may not be the heaviest that the motor will ever have to carry. If a continuous-duty motor, with rating equal to the heaviest load that it will ever be called upon to carry with the machine tool in question is purchased, its temperature rise, tested in accordance with its rating, will be much higher than will be attained under service conditions, where it will probably operate as a 40-deg. motor. The same temperature rise under both conditions may be obtained by using a motor of lower rating, but in this case the motor will have to carry heavy overloads in service. By reducing the time rating to two hours, or one hour, or less, it will be possible to get a motor of a rating equal to the maximum load that must be carried in service and giving a temperature approximating that which will obtain in service. It is, however, merely a continuous-duty motor of lower horsepower which is tested on overload for the period in question. It should also be noted that a one-hour test is likely to give a shunt-field temperature rise that is materially less than would be obtained under service conditions, where the shunt field is likely to be excited almost continuously.

Claims for 50-Degree Motor Doubtful

The superiority of design claimed for the 50-deg. motor is, from the purchaser's viewpoint, somewhat doubtful. The first cost of his motor will be lowered, provided he is not compelled to order a motor of higher rating than he would under the old standard. It may be assumed that the efficiency is practically unchanged, as the 40-deg. motor shows a rather flat efficiency curve in the vicinity of full load, sometimes rising and sometimes falling as the full-load point is passed. If any claims are made for superiority in commutation or speed regulation, they are not backed by definite figures and guarantees. As a practical manufacturing proposition it is necessary to utilize the same frame for motors of different ratings; the use of other standard parts may be governed by the frame size or by shop expediency rather than by purely theoretical considerations. It therefore cannot be expected that all motors built in the same (or different) frames will show the same operating characteristics. Any change in design necessitated or allowed by the change in temperature rating would be influenced by the same practical considerations, and we may, therefore, reasonably expect that there would be an improvement in the motors furnished in some cases and the reverse in others.

On account of the aforementioned differences in operating characteristics the engineer who desires to purchase the most economical motor for a given purpose must not only know the character and amount of the load, but also the true operating characteristics of the motor he is buying. For the latter he must usually depend upon experience, the motor manufacturers seldom being willing to furnish them. As an illustration we may assume that the load is practically constant at 8.5 hp.; the engineer has found through experience that a 7.5-hp. 1,150-r.p.m. motor of a certain make will give satisfactory service as it has a comparatively low temperature rise at its rated capacity. On the other hand, the 7.5-hp. 1,750-r.p.m. motor of the same make may be unable to carry the load for the reason that it has a comparatively high temperature rise at its rated capacity. With the intermittent and fluctuating loads of the ordinary machine tool and the purchase of a motor with a one- or two-hour rating, the case becomes more complicated but is effectively the same. This is equally true for both the 40- and the 50-deg. motor, but the change from one to the other destroys the knowledge he has gained and he will be compelled to begin to collect new data. Perhaps the 10-hp. 50-deg. motor is the identical machine that he previously obtained as a 7.5 hp., while the 20-hp. is exactly the same as it was before and the 25-hp. is different from any motor previously furnished. Until he has gained experience, the engineer will be compelled to order a motor of the next higher rating than the 40-deg. motor previously used, which may be correct or may give a heavier motor than necessary.

Alternating-Current Squirrel-Cage Motors

From the purchaser's viewpoint the improvement in the direct-current motor must be principally in cost, the operating characteristics of the 40-deg. motor being satisfactory. With the alternating-current squirrel-cage motor the starting torque and pull-out torque are frequently of great importance; in fact, they may determine whether or not this type may be used. The guarantee of the manufacturer in regard to torque generally conforms to that specified in the handbook of the Electric Power Club; but the purchasing engineer knows from experience that certain motors exceed that value very materially; with a change in design this knowledge becomes obsolete. Let it be assumed that a 25-hp. squirrel-cage motor be designed with all possible refinements permitted by the 50-deg. rating and that the actual starting and pull-out torques are respectively 125 and 200 per cent of the full-load torque. Reduce the rating of the motor to 20 hp., and it will become practically a 40-deg. motor; the actual value of the starting and pull-out torques measured in foot-pounds will remain unchanged, but will be 156 and 250 per cent of the full-load torque in place of the former values. To this extent the operating characteristics of the 40-deg. motor are superior to the 50-degree.

It has also been stated that the majority of plants are overmotored, resulting in low power factor on alternating-current systems and lower efficiency and unnecessary expense in all cases. This fault would be corrected by substituting 50-deg. motors of the same rating for the 40-deg. motors now in use. The purchaser naturally wishes to judge for himself the capacity of the motors he installs. The interesting point in regard to the majority of plants being over motored is the cause leading to this condition. In the writer's opinion it is the result of experience; motors are purchased that have been found to give the most satisfactory service for driving the equipments in question, regardless of any exact measurements of the horsepower required; and these motors are the ones which, on account of being slightly underloaded, run with a comparatively low temperature rise.

Breakdown of Insulation

In the foregoing no question has been raised as to the validity of the fundamental claim of the advocates of the 50-deg. motor; namely, that breakdown of insulation is not caused by operating at temperatures not exceeding 105 deg. C. (see quotation in second paragraph). Among the "various causes" of breakdown it is believed that many are at least influenced by the tem-

perature at which the insulation has been previously operated, even though it is very materially below the 105-deg. limit. Prominent among the direct causes of breakdown are moisture, the effects of oil upon the insulating material, the penetration of copper or carbon dust probably assisted by oil, mechanical breakdown of insulation due to the vibration of the motor as a whole, vibration and stresses due to the operation of the motor under load, momentary abnormal voltage due to induction or other causes, and mechanical injury from external sources. It is doubtful if anyone having experience with motors will maintain that one that has seen several years of service, even at low temperatures, is as well able to withstand the effects of moisture and the other causes of breakdown as a motor of the same type fresh from the factory. On the new motor the insulating varnish is very tough and elastic and covers practically all the insulated surfaces with a continuous smooth coating that is almost impervious to water, oil and dust. The varnished cloth and various grades of paper insulation are also tough and elastic. On the old motor it will probably be found that the varnished surfaces have lost their gloss and contain many fine cracks, and there may also be places where the varnish has flaked off. Cotton and paper or fiber will be found to be brittle if not actually broken, and it is not unlikely that shrinkage will have left open spaces for the admission of foreign matter or permit vibration of parts that were originally held firmly in place. It does not appear probable that these changes in the *mechanical properties* of the insulation, which directly affect its ability to withstand service conditions, are due to time only and are independent of the temperatures below 105 deg. during the period in question.

Effect of Temperature on Insulation

A "Report on the effect of temperature on insulating materials" by the "Engineering Standards Committee" throws some light on this question and, although published in 1905 and dealing with material used in Great Britain at that date, should be applicable to the cotton, paper and varnish ordinarily used by motor manufacturers in this country today. Samples of various materials were subjected to temperatures of 75, 100 and 125 deg. C. for twelve hours during each working day for a year. At the end of each month the strength was measured by the pressure required to punch a hole one-half inch in circumference with a steel punch; brittleness was also tested by bending with the fingers. Some of the results obtained are tabulated here. Each of the figures given in the table is the average of ten readings. The various discrepancies that may be readily noted are therefore due to lack of uniformity in the material. Taken as a whole, the table appears to justify the following conclusions:

Press Spah closely resembles fish paper and shows but little change in strength at normal temperature. At 75 deg. there is a marked decrease in strength at the end of the tenth month, which is likely to become more marked with periods exceeding twelve months. At 100 deg. the deterioration is marked at the end of the fifth month and at the end of twelve months the strength is about 40 per cent of its original value.

Empire Cloth—At normal temperature there is a slight decrease in strength at the end of the ninth month, which does not materially increase for the following months. At 75 deg. the strength is about 50 per cent of normal at the end of the first month, and at the end of the ninth month a rapidly increasing deterioration begins.

Calico with Electric Varnish—At normal temperature no marked deterioration is shown, although the readings are somewhat erratic. At 75 deg. the readings are also erratic, but show marked deterioration at the end of the ninth month, which does not materially change during the remaining three months. At 100 deg. the deterioration is more marked than at 75 degrees.

Calico with Voltalac Varnish—No deterioration is shown at normal temperature. At 75 deg. the material shows a falling off of about 25 per cent at the end of the first month and from that time remains fairly constant up to the end of the eighth month, after which the deterioration is rapidly accelerated. At 100 deg. the deterioration is much more serious.

Results of Bending Tests

Bending between the fingers shows the following:

Press Spah—After one month at 125 deg. breaks on bending, after eleven months at 100 deg. breaks on bending, and after twelve months at 75 deg. cracks on bending.

Empire Cloth—After one month at 125 deg. breaks on bending, after two months at 100 deg. cracks on bending and breaks after five months; after ten months at 75 deg., breaks on bending.

Calico, Electric Varnish—After one month at 125 deg. is brittle; at 100 deg. breaks on bending after two months; at 75 deg. after five months cracks on bending and breaks on bending after ten months.

Calico, Voltalac Varnish—At 125 deg. is very brittle after two months; at 100 deg. cracks on bending after three months and breaks after five months; at 75 deg. cracks after ten months and breaks after eleven months.

In view of the foregoing data it is difficult to believe that the ordinary insulating material of today will not suffer rather rapid deterioration at a temperature of 105 deg. C. or that a temperature as high as 125 deg. C. will not be frequently attained by the so-called 50-deg. motor with its temperature determined by ordinary test-floor methods.

EFFECTS OF TEMPERATURE ON INSULATING MATERIALS

	Material															
	Press Spah				Empire Cloth (Oiled Calico)				Calico Impregnated with Electric Varnish				Calico Impregnated with Voltalac Varnish			
	Temperature, Deg. C.				Temperature, Deg. C.				Temperature, Deg. C.				Temperature, Deg. C.			
Months	Normal	75	100	125	Normal	75	100	125	Normal	75	100	125	Normal	75	100	125
	Pressure in Pounds				Pressure in Pounds				Pressure in Pounds				Pressure in Pounds			
1	233	241	234	88	44.1	26.0	12.8	13.2	40	28	25	12	57	42	15	7.4
2	230	242	187	69	45.6	26.0	5.5	4.2	36	27	27	13	49	38	7.2	3.1
3	254	261	228	84	47.0	23.0	9.8	11.6	40	36	3.8	2.8	51	38	10.6	6.7
4	213	242	215	84	34.0	11.5	5.0	5.0	32	25	16.6	5.5	51	32	5.0	2.5
5	201	244	184	79	42.0	16.0	9.0	6.2	40	27	22	16	52	36	9.2	5.4
6	257	232	157	86	51.0	24.0	7.2	....	38	25	22	10.2	60	30	5.7	5.0
7	239	252	199	63	42.0	23.5	8.6	....	22	37	23	6.0	45	30	5.0	4.6
8	232	263	175	48.6	43.0	20.0	9.0	....	37	30	23	6.0	45	30	5.0	4.6
9	235	240	131	36.5	32.0	15.5	6.0	....	31	16.4	11.6	8.3	50	10.7	4.0	...
10	214	194	117	....	43.7	16.5	....	....	37	22.1	....	....	52	8.3	....	...
11	199	216	83	....	39.0	11.5	....	....	27	11.5	....	....	52	5.6	....	...
12	215	173	97	....	33.0	5.0	....	....	29	31.0	....	....	52	5.0	....	...

Setting Valves on Marine Diesel Engines

By LOUIS R. FORD

DIESEL engines when sent out from the shops, excepting in the case of small units, are disassembled and must necessarily be re-erected in the ship. One of the last things done before the engine is turned over under its own power is the careful setting of all valves. This is the time for the ship's engineer to begin to familiarize himself with the valve setting on his particular engine unless he has had an opportunity to acquire experience on the erecting and testing floor in the builder's shops.

Before discussing methods of valve setting, the order of timing should be understood. Considering a typical large engine of the four-stroke-cycle type, such as is used in cargo ships, and taking the cams of one cylinder in the order in which they operate, the succession is as follows: Five degrees before top center the spray valve is opened by its cam, which holds it open through 54 deg. of a revolution of the crankshaft. After the spray valve closes, expansion occurs until 138 deg. from the top of the stroke, when the exhaust valve opens and remains open until 14 deg. past top center. At 22 deg. before top center, on the upward stroke of the piston, the inlet valve opens and stays open until 34 deg. past bottom center. After the inlet valve closes, all valves remain closed until 5 deg. before top center, at which point the spray valve opens again. The air-starting valve operates only when the engine is being maneuvered. It opens when the piston is just past top center and remains open throughout about 128 deg. of revolution. In Fig. 1 appears a typical marine Diesel timing.

Valve Events Are Usually Marked on the Dial Plate

Most engine builders attach a dial plate to some moving part of the engine, on which all the valve events are plainly marked with radial lines which register with a fixed pointer attached to a stationary part of the engine. A satisfactory substitute for this dial plate is a set of marks on the rim of the flywheel. If the engine is not thus equipped, the engineer should mark the flywheel, with the builder's valve diagram as a guide, using a set of ordinary alphabet and number stamps to make permanent marks that will not become effaced. In addition to marking the valve events on the flywheel, the rim of the wheel should be marked in degrees around its periphery and the top center for each crank should also be marked on the wheel. On crosshead-type engines the procedure, familiar to steam engineers, of marking the guides, can be made use of to find the dead centers.

Whenever work involving any change in the valve gear is done on the engine, the valve timing should be checked before any attempt to run is made. While the correct timing of all valves is essential for satisfactory operation of the engine, it is of utmost importance that the fuel injection or spray valve be correctly timed. A slight error in the timing of this valve will have a very noticeable effect on the power and fuel consumption of the engine. When an engine is first built, the valves are timed according to the designer's valve diagram, but these settings are always verified on the test floor by means of indicator diagrams. On shipboard, unless the engineer has an indicator he must necessarily set the valves according to the valve diagram or, in the absence of such a diagram, must estimate the times of openings and closings from his knowledge of general practice. There are undoubtedly many engines that have been in operation for long periods without ever having been indicated to test the valve timing, and the operators of such engines may have come to regard the use of an indicator as a useless refinement. It is safe to assume that such engines could be improved both as to smoothness of operation and fuel consumption if the valve settings were checked by the use of an indicator. The assertion that such engines do run may be answered by the statement that there are many men working who have valvular heart trouble, but they are not as good as the more fortunate persons whose heart valves are all right.

When it becomes necessary to reset the Diesel-engine valves on shipboard, the engineer must first, unless he

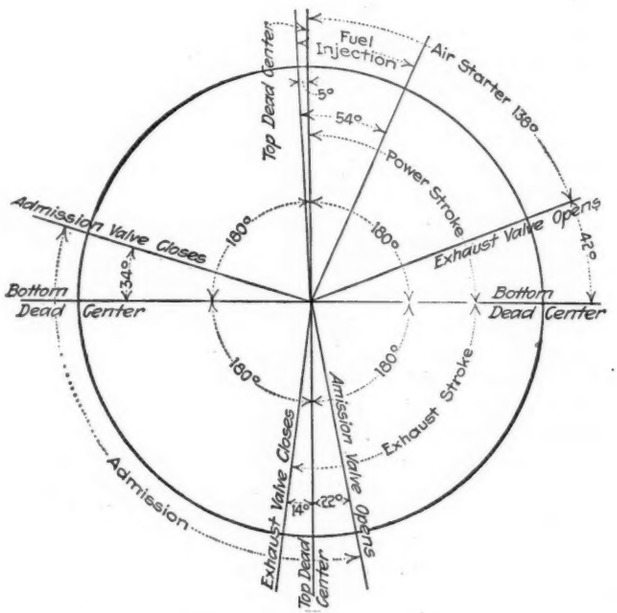


FIG. 1. TYPICAL MARINE DIESEL TIMING

is already familiar with them, learn the settings from the builder's valve diagram or have recourse to the flywheel or dial-plate marks. It is, of course, essential that the clearance between the rollers and the zero circle of the cam be set for the correct amount before the timing is adjusted, as variations in the amount of clearance will affect the timing and the duration of opening of the valve. On large engines the spray-valve cam-roller clearance is usually 0.005 to 0.006 in. and the inlet- and exhaust-valve cam-roller clearance, 0.025 to 0.026 in. This clearance can be measured by using feeler gages between the cam and roller. Adjusting screws are usually provided at the point where the valve levers are attached to the valve stems.

The point at which each valve opens is what the engineer is chiefly interested in. Having established this point, he has very little control over the point of closure, since that is determined by the profile of the cam. It

can be regulated, within narrow limits, by adjusting the cam-roller clearance. This point will be discussed later. Having jacked the engine until the camshaft is in such a position that the valve being set is near the point of opening, the signal for very slow turning is made and the man at the turning gear causes the engine to approach the point of contact between cam and roller by a series of jerks. At the instant the valve starts to open, the engineer signals for stop and the position of the crankshaft is read from the dial plate of the flywheel.

Ordinarily, only the spray-valve cams are made adjustable. This being the case, it is only this valve whose time of opening may be changed. If it is found that at the time of opening of the spray valve the crankshaft has turned beyond the point at which the valve should open, the adjustable cam toe is moved in a direction opposite to the direction of rotation of the camshaft, and vice versa for late openings. Knowing

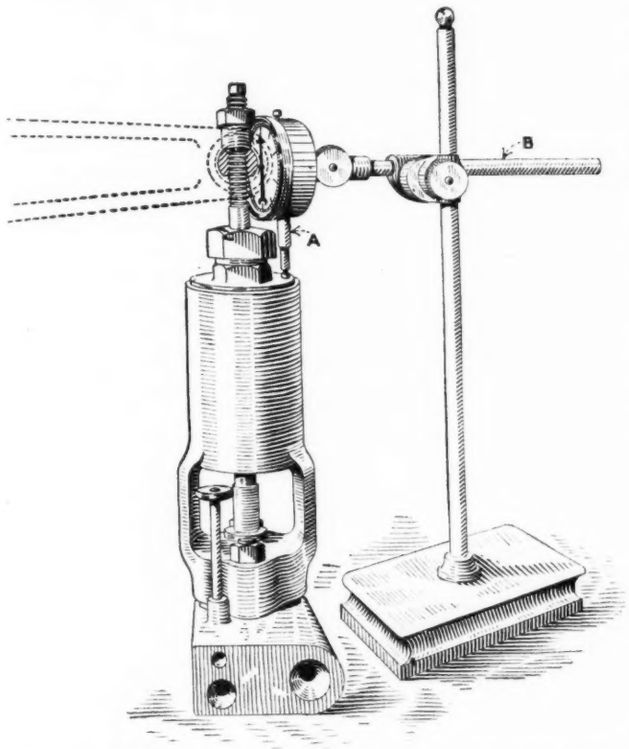


FIG. 2. SETTING FUEL VALVE WITH A DIAL INDICATOR

the number of degrees it is desired to retard the valve opening, the engineer should know from experience the number of turns or the fraction of a turn to give the adjusting screw. If the cams are not provided with screw adjustment, the amount to move the cam toe must be estimated. The turning gear is then reversed, the engine turned backward enough to take up all lost motion, then turned ahead and the point of valve opening again taken.

How to Determine When the Valve Lifts From Its Seat

There are several ways of determining the exact time the valve lifts from its seat. An approximately correct method is to start revolving the cam roller when the cam toe is just about to make contact. When contact between the cam and its roller has progressed sufficiently to jam the roller so that it cannot be turned, the valve may be considered open. This method is not accurate, as the clearance in pin bearings, deflection in levers, etc., may result in the valve leaving its seat an appreciable time after contact between cam and roller is made. A second method, which can be used when setting spray valves, is to turn the spray air into the spray valve, open the indicator cock on the cylinder, then listen for the hiss of the air that blows into the cylinder when the valve opens. This method works very well with small engines, but in the case of a large engine in which the cylinder volume near the time of fuel admission is quite large relative to the area of the hole through the indicator cock, a slight movement of the piston causes quite a rush of compressed air through the indicator cock and it is not always possible to determine the exact point of spray air admission.

The most satisfactory method of all is to make use of a dial test indicator such as is generally employed in machine shops. This instrument is shown in Fig. 2. The instrument may be used on its base, or the arm *B* may be removed from its holder and clamped to any stationary part of the engine structure near the valve being set. Pointer *A* is placed in contact with the valve stem and any movement of the stem will be registered by the hand on the dial. The dial can be read to one-half of one-thousandth of an inch, so the exact point of opening of the valve is easily determined. By this method all error due to lost motion in the valve gear is avoided, as only the actual valve movement affects the indicator.

Having set the valves to open at the correct point as called for by the builder's valve diagram, the time of closing and total lift should be measured just as a matter of record. If the dial test gage is used, the maximum lift may be read directly from the dial. The same measurements should be taken for the astern cams.

Checking the Valve Settings With Indicator Diagrams

It is not always possible to operate the engines for any great length of time while alongside a dock or at anchor, and even when it is done full speed cannot be obtained. For these reasons, unless some radical change of adjustment has been made, the taking of indicator diagrams to check the correctness of the valve setting may well be deferred until the ship is under way at sea. After an engine has been in use for a considerable time and the valve settings have been checked several times with indicator diagrams, the correct setting should be so well established that no further indicator work should be necessary in this connection, but since frequent indicator diagrams are taken on well-regulated ships as a test of compressions, combustion, piston and valve tightness, etc., the valve timing can be frequently observed.

It is not an unusual thing for the spray valves on an engine to vary as to time of opening. If each valve is set to open, say at 5 deg. before top center, it may be found upon taking indicator cards that one or more valves may be slightly late or slightly early and it may be necessary to vary the times by as much as one degree in order to get a good combustion line. This variation may be due to slight differences in the cams or in the spray valves. This is the principal reason for checking the settings with indicator diagrams. As previously mentioned, however, after the correct timing is once established, it is not likely to change. It is not safe for the engineer to assume that the builder has correctly established the timing for each cylinder; the only way

to be sure is for him to make the tests himself after the engines have been placed in the ship.

It may sometimes happen that the locknuts on the adjusting screws which control the clearance between rollers and cams may work loose while the engine is running and the adjusting screws will turn, so as to reduce or increase the clearance. An interesting example of the effect of this action is shown in Fig. 3—reproductions from actual indicator cards taken from

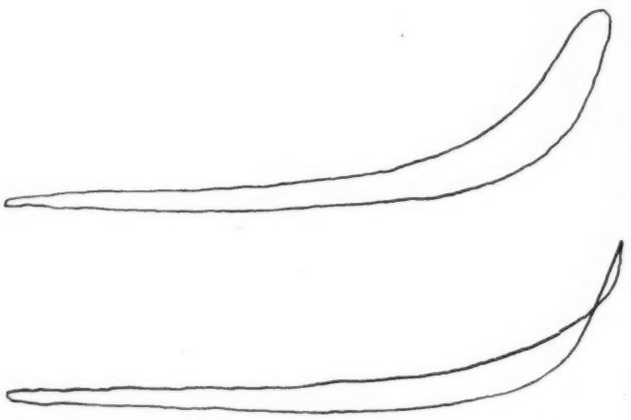


FIG. 3. MARINE DIESEL INDICATOR DIAGRAMS

one cylinder of a very large marine Diesel engine that had been in operation several days. Cards taken previously showed the spray valve on this cylinder to be timed correctly, and when the lower card shown in Fig. 3 was taken an investigation was made to determine the reason for the very late injection of fuel. It was found that the adjusting screw at the connection between spray-valve stem and the valve lever had loosened and the nut was turned, by the vibrating of the engine, in such a direction as to increase the clearance between roller and cam, consequently the cam was late in lifting the valve and the duration of valve opening was greatly reduced. The clearance was readjusted while the engine was running, by screwing back on the adjusting screw until the roller remained in contact with the cam and could not be held from spinning; then the adjusting screw was set up until the roller could be held stationary by holding the thumbs against it. The upper diagram shown in Fig. 3 was then taken. In this case the engine gave no indication of any wrong adjustment and it was discovered by the indicator. If the adjusting screw had been turning in the other direction, so as to decrease the clearance, it would soon have reached the point where the spray valve would remain off its seat and trouble would have resulted.

When interpreting an indicator diagram with a view to determining the correctness of valve settings, particularly the spray-valve setting, the engineer should avoid being misled by certain combustion-line characteristics that result from conditions outside the spray-valve gear. If a good combustion line is obtained with oil of, say, 24 to 26 deg. Bé. gravity, a diagram having all the characteristics of retarded admission will be obtained if oil of 22 deg. Bé. gravity is used and the same spray-air pressure maintained. Conversely, with the same grade of oil a diagram showing too early admission may be obtained by increasing the spray-air pressure.

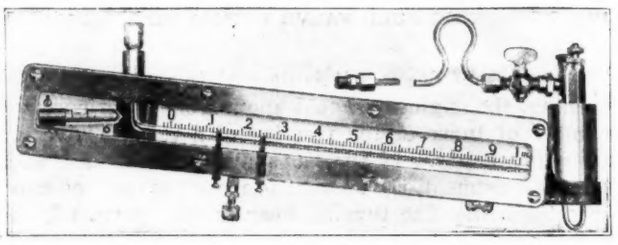
Lubrication of the pin bearings on which the spray-valve cam rollers turn is important, and its neglect may introduce puzzling irregularities in the combustion line on the indicator diagrams. If a cam roller binds on its pin and is not free to revolve under the influence of the cam, a flat spot will wear in the roller very quickly. If the roller is subsequently freed or partly freed of its pin, it will turn and sometimes contact between cam toe and roller will be made on the high part of the roller, sometimes on the low part, so that the time of admission will vary, causing the irregularities just mentioned. The watch routine should call for frequent examination and oiling of these rollers. At each examination the thumb should be pressed against each roller; if this thumb pressure does not stop the spinning of the roller after it drops off the cam toe, there is insufficient clearance between cam and roller. On the other hand, too much clearance can be found by visual examination. On very large engines, where the valves and valve gear are very heavy, too much clearance will result in noisy operation of inlet and exhaust valves, a loud slam resulting from each valve closure.

New Ellison Differential Draft Gage

The tube inclination of the new Ellison differential draft gage is approximately $1\frac{1}{8}$ in. in 10 in. for multiplying ten times and $\frac{9}{16}$ in. for multiplying twenty times, which is about the lowest permissible inclination for the length and bore of the tube used in this gage. Below this inclination, discrepancies appear, increasing as the tube approaches horizontal, where maximum interferences occur. The steep incline is essential for accuracy, quick and correct leveling of the liquid to zero, and rapid drainage from zero and return thereto. repeating under wide temperature changes. The indicating tube being in the center line of the chamber, the readings are not affected by the transverse tilting of the chamber.

To avoid glass breakage from unequal expansion and contraction of the glass, cement and metal in a level cemented full length, the level of the gage under discussion is cemented at one end only. The level glass may expand freely into space and is relieved from all temperature stresses prevailing under high temperature variations in the room.

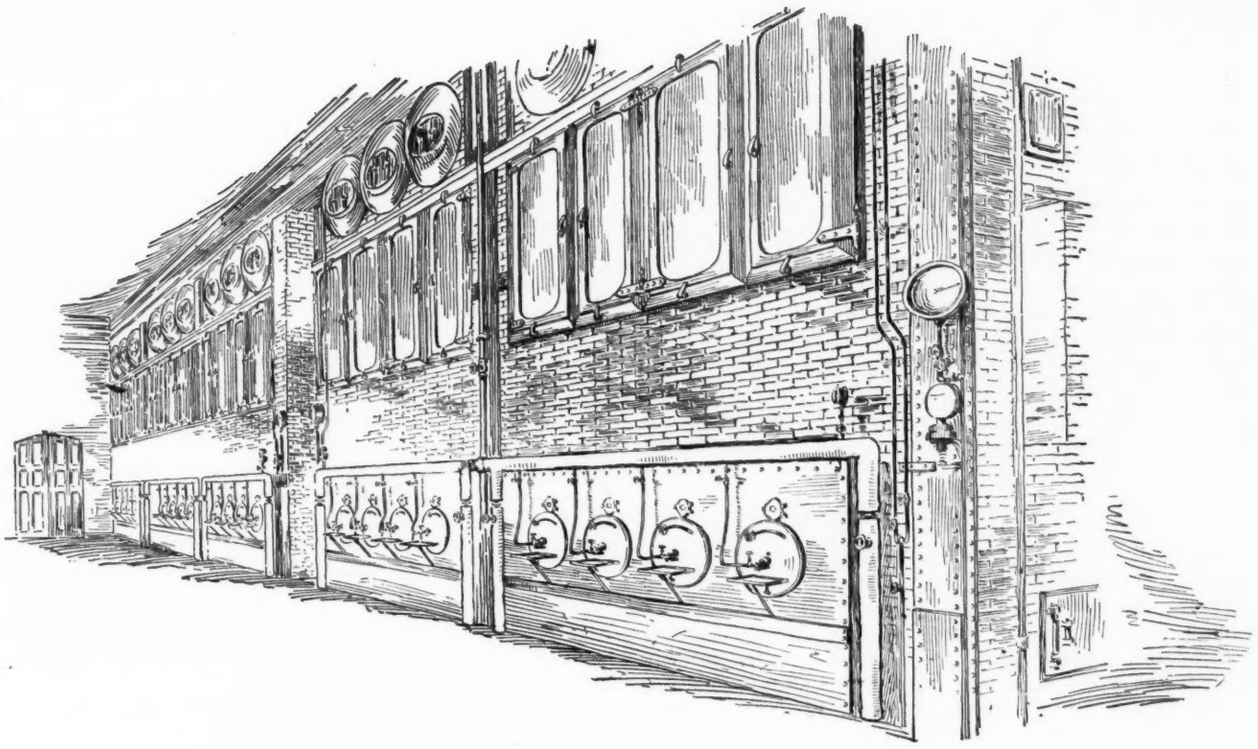
In filling the gage with liquid to zero, slight variations are leveled with a plunger. The plunger may



NEW ELLISON DIFFERENTIAL DRAFT GAGE

also correct for future variations due to temperature changes.

For preventing the liquid pulling through under high momentary draft, a U-type seal of "nickel-silver" tubing, $\frac{3}{32}$ in. outside diameter, having $1\frac{1}{2}$ in. range in excess of the scale reading, is provided. The seal permits a short gage of high liquid multiplication and of low range. This gage is made by Lewis M. Ellison, Chicago, Ill.



Efficient Handling of Fuel Oil—I

By ALLEN F. BREWER

THE primary object in the firing of oil is to obtain the most perfect atomization, or breaking up of the oil, in order to permit of a thorough mixture of the particles with the air for combustion. Every particle must be completely surrounded by air, and the gases must be kept at the ignition temperature until combustion is complete. There is, of course, no definite means of determining whether this is actually taking place. There are, however, certain principles of operation and indications of flame and stack, all of which have been developed by experience and long practice on the part of oil-burning engineers, which are of invaluable aid to the present-day wide-awake fireman.

It is the purpose in this article to depart from the theoretical point of view as much as possible, presenting purely the practical "kinks" and principles of operation, which it is hoped will guide the fireman in gaining better combustion from his oil and improving his own efficiency by the efficiency of his boilers. The general procedure in starting an oil fire will depend on the type of burner in use—steam, air or mechanical atomizing. Whatever the burner, however, there are two general cautions: Prior to any operation see that all valves that should not be open are *closed;* before lighting be sure that all lines are free from leakage, dirt, scale, etc.

The efficient handling of oil fuel and the "tricks of the trade" involved are daily becoming of more vital importance to the ambitious fireman, whose interest in his company must be shown through the operation of his boilers. In many cases his relation to the fuel problems of his company will be confined almost entirely to the actual combustion of oil under his boilers. His oil education, however, should not cease at this point; he should strive to cover the entire field of practical fuel-oil handling. It is for him that this series of articles is prepared.

With a steam burner the method of lighting will depend on whether steam is already available from some other boiler or not. If there is no steam, build a wood fire in the furnace and get up sufficient pressure to atomize the oil to be fired; a pressure of about fifteen pounds will suffice. Build the fire well toward the back of the furnace so as not to injure the burner tip. From this point procedure is the same as if steam were available at the start. That is, start the oil pump, open the steam valves to the burners, blow out the steam side and also the oil side of the burners, if possible until no more drip appears (the burners are then well heated) and the steam seems thoroughly dry.

A bypass valve can always be installed between the steam and the oil lines and is recommended, to enable the oil line from the burner valves to and through the burners to be blown clear whenever desired. This insures against excessive clogging and possible need of cutting out the burner for any length of time. To ignite use a metal torch not less than four feet long with a bunch of oil-soaked waste tied to one end. Light the waste and push the torch in through the peephole, holding the flame close to

the burner tip. Then open the oil-line valve sufficiently to allow a medium spray to be formed, which should promptly ignite; if it does not, adjust the oil valve further until ignition does occur. Do not stand directly in front of the furnace when lighting off, because there is the danger of a flareback. If the peephole is not located so as to allow convenient use of a torch, light a bunch of oil-soaked waste and throw it into the furnace as directly in the path of the blast as possible; then open and adjust the oil valve as when using a torch. When using a flat-flame burner the torch is by far the most convenient and certain means of lighting off. When preliminary steam has been raised by a wood fire it will frequently be possible to discard the use of lighted waste to ignite the spray, allowing the latter to light from the incandescent wood embers. This may develop into dangerous practice and is advised against.

Starting a Fire with Air Burners

In using an air burner the points to observe in starting the fire are much the same as in using a steam burner; no preliminary wood fire will be necessary unless there is no steam available to operate the air compressor. When such is the case it will probably be necessary to raise the steam pressure somewhat above fifteen pounds on the line. This will depend, however, on whether there is a main and an auxiliary steam header or only the main, the location of the steam line to the compressor and the general layout of valves, etc. Only practice and construction can guide the operator in such a case.

With the air compressor under operation the method of lighting off and adjusting the valves is similar to that described for steam burners.

The air-atomizing burner is operated in general very much the same as the steam burner; in fact, many types can be used for either steam or air. The principles of operation are practically the same both in starting and general usage.

How To Use Mechanical Burners

The use of mechanical burners is confined to a large extent to marine practice. With no steam available on the lines a hand pump is necessary to bring the pressure on the oil line up to about 200 pounds and maintain it at such pressure until sufficient steam pressure has been raised to operate the main oil pumps. It must be remembered that the mechanical principle of burning oil is based on the idea of forcing the oil through the burner at sufficient pressure to atomize it properly. With the hand pump in proper operation, open the air valves, dampers and registers wide to admit as much air as possible. Pass a lighted torch in through the peephole and hold it as close to the burner tip as possible. Then open the burner valve full, when the oil spray should ignite. Failure to ignite, if the burner is clean, will probably be due to the oil temperature being too low and the viscosity too high. Constant contact of the torch will, however, raise the temperature of the spray sufficiently to cause final ignition. Keep the hand pump in operation until the steam pressure has been raised to about 100 pounds. The main oil pump can then be started, as well as the other auxiliary apparatus, such as the blower, etc., and the hand pump discarded.

With steam on the lines the procedure of starting is simplified. Be sure to see that there is ample draft to prevent flareback. It is assumed that the main oil pump and oil heater (if one is installed) are already in service. Pass a lighted torch in through the peephole and hold the waste end close to the burner tip; open the burner valve full and the burner should light immediately. If it fails to do so for any length of time after constant contact of the torch, an inspection should be made of the tip to see whether it is partly clogged or dirty, etc. After the burner is ignited the air vanes and oil valve can be regulated according to the load, and to maintain a "feather of smoke" condition at the stack.

Never forget to watch a newly lighted burner carefully, particularly in cold weather, until the furnace is well heated, since the flame may go out owing to irregularities in the oil flow, low temperature of the furnace, etc. During warming up smoking will generally occur until the furnace and gas passages have become heated. Then proceed to regulate for flame appearance and smoke film at the stack.

In every instance when starting a burner under a cold boiler and no steam is available to run the main oil heater, an auxiliary heater fired by external means will be found useful in bringing the oil to a viscosity sufficient to render its flow fairly uniform, and preventing the burner from going out.

(The next article of the series will treat of the indications of efficient operation.)

Wood As Fuel For Boilers

By M. Kammerer

Whereas the great scarcity of coal is driving French industry to the use of wood for firing boilers, the scarcity of wood itself makes efficient combustion most desirable.

Assuming a water content of about 20 per cent, from $1\frac{1}{8}$ to $1\frac{1}{2}$ cords of hard wood or $1\frac{5}{8}$ to 2 cords of soft wood are equivalent to one ton of bituminous coal with a heating value of about 10,000 B.t.u. per lb. A larger grate surface is needed for wood than for coal, owing to the larger volume of the fuel for the same heating value. Moreover, the high content in volatile substances gives a very long flame and the height of the furnace should be increased between 40 and 60 per cent to prevent the flames coming in contact with the water tubes until combustion is completed. With such a height of furnace it is possible to obtain a rate of combustion of 40 lb. of wood per square foot of grate surface and an evaporation rate substantially the same as with coal.

The greatest trouble experienced in wood-fired boilers is in avoiding a large excess of air. Even by cutting down the draft as much as possible, while still maintaining complete combustion, it is difficult to obtain more than 8 to 10 per cent of CO_2 in the flue. The best way of decreasing the losses through a large excess of air is to keep the section of the logs down below 4 x 4 in., to start the fire with coal, and burn the wood over a bed of coal cinders, and to use a much deeper fire than with coal. It is possible in this way to raise the proportion of CO_2 in the flue to 13 or 14 per cent and still have complete combustion. An over-all efficiency of 80 per cent may be obtained in this manner.—*Bulletin de la Société Industrielle de Mulhouse.*

It pays to keep the engine room clean and every tool in its place. A wrench board is a great asset around a plant.

Oil in the Expansion Coils of the Refrigerating System

By F. L. Brewer

As the overhauling and cleaning season for ice plants approaches and the engineer is contemplating work that should be done during his slack time to put the plant in the best condition for the next season's run, he would no doubt find in going over his notebook that the coils of certain tanks were to be blown out to remove the oil that had accumulated in them. The best way to keep an apparatus clean is to use every care to prevent it from becoming dirty, rather than to wait until a dirty condition arises and remedy it by periodical cleanings. The question will naturally arise, If there is oil in the coils, what is the cause and what can be done to keep it out of them?

How to Keep the Oil Out

In answering the latter question, one way is never to use an oil for the lubrication of compressors unless it is known to be suited to the conditions existing. The chief requisite is the cold test. Any oil, regardless of any other good qualities that it may possess, which will not withstand a zero cold test without congealing or becoming thick should be considered unfit. Do not use any more oil than is absolutely necessary for the proper lubrication of the pistons, rods and valves, and do not let the separators fill up before blowing them out. If separators were perfect in their action and were blown out at regular intervals, of course the oil troubles would end right there. Unfortunately, such is not the case, for some oil will pass the separator regardless of every care that may be taken, but if the separator is allowed to fill up, it cannot remove any of the oil.

After passing the separator, the next place in which the oil would accumulate is in the top of the liquid receiver, for oil is lighter than liquid ammonia. The liquid from the condenser, with any oil that may be present, enters the top of the receiver, and here the separator should really be more perfect than when the gas passes through the oil separator, for the liquid, being heavier, should immediately fall to the bottom, leaving the oil floating on the surface. For this reason it would appear that a surface blowoff in the receiver would be of great assistance in the removal of any oil that had passed the separator. This conclusion was reached after pumping out several receivers in plants that were not experiencing any trouble whatever from oil in the coils, and finding several gallons of oil in the receivers. One of the receivers contained at least twenty-five gallons of pure oil. The reason that the oil had not passed to the tank coils was that the outlet pipe extended down nearly to the bottom of the receiver, so as to maintain a liquid seal.

Amount of Oil Required

There can be no set rule as to the amount of oil required by different machines under varying operating conditions. In general, the higher the temperature of the discharge gas, the more oil will be required. This applies particularly to double-acting compressors and especially to vertical machines of this type. It is sometimes necessary to tap the upper suction-valve housing of a vertical compressor and feed a small amount of oil directly into the valve to secure sufficient lubrication for the proper valve action. When the oil is introduced through the suction header, it seems that most of it passes to the lower suction valve on some of these machines. This is a condition requiring the maximum use of oil. Again, in several instances that have come under the writer's personal observation, vertical single-acting compressors have never received any oil except that pumped into the suction pipe during the first few months of their operation or the oil that later entered through the stuffing-box packing.

As evidence that oil in the coils is more an imaginary than a real cause of the falling-off in capacity of an ice tank, I would call attention to the practice of some of the ice-machine manufacturers who equip their machines with lubricating devices that feed oil directly into the suction pipes, also to the excessive amount of oil that the first high-speed machines threw over into the high side. This oil passed in such large quantities that a great deal of it got to the separator and the receiver and found its way to the expansion coils, but it never became necessary to stop and blow out these coils. In justice to the makers of some of the high-speed machines it might be well to add that the trouble referred to has been overcome largely by fitting an extra ring to the lower part of the piston, similar to the rings used on automobile engines, and by carrying a lower oil level in the crankcase.

How the Oil Can be Removed

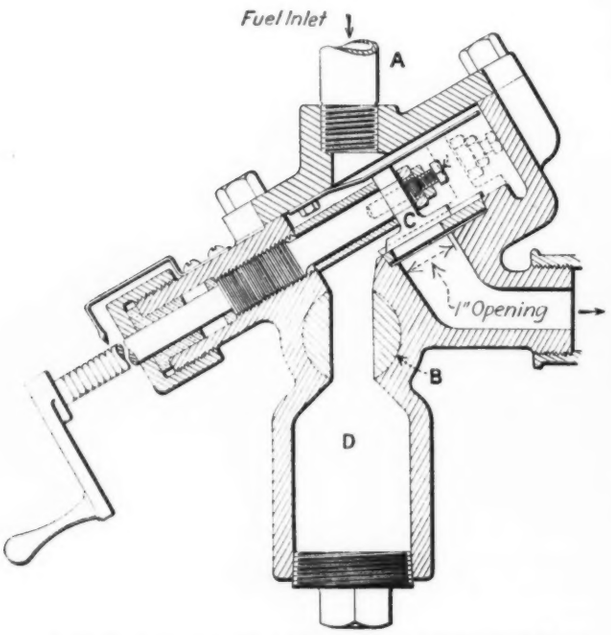
Having shown how and why oil gets into the coils, the question naturally arises, If the coils are not disconnected and blown out individually, how can the oil be removed? As a first consideration experience teaches that before oil can enter the coils in sufficient quantity to retard efficient operation, or in other words to so insulate them that the heat transfer from the brine to the ammonia will be lowered, trouble will be experienced by the expansion valves clogging up, as this, of course, is the first cold point that the oil encounters. The openings of these valves being restricted, frequent manipulation will be required to keep them working, and unless the operation is thoroughly understood a great variation of the suction pressure will result. This will cause the evaporating temperature to be too high at times for the brine, and at other times the pressure will be so reduced that sufficient weight of ammonia cannot be handled to produce capacity.

To present the writer's idea of how the oil (with the exception of a thin film which adheres to the pipe surfaces) passes out of the coils, assume that the surfaces have become quite heavily coated with any standard brand of oil that is suited for the conditions existing in the operation of ice tanks or refrigerating coils when working under ordinary temperatures. If the oil has anything like a zero cold test, it should run quite freely at fifteen to twenty degrees above zero, so that at any time the machine is stopped or when the pressure, and consequently the temperature, rises, the oil will run down to the bottom of the pipes, and upon starting the circulation of the ammonia in the coils under this higher temperature, the oil will be carried along with it toward the compressor, and on reaching the separator a large part of it will be deposited and can be blown out.

No oil-engine plant should be without a system of records. Unlike a steam plant, only three readings are vital; these are the fuel-oil consumption, the lubricating-oil consumption and the power output.

Rigby Liquid-Fuel Regulating Valve

There are many kinds of liquid fuel, and each is found in a number of grades, which do not run uniform. For this reason it is necessary to use some sort of regulating valve that will compensate for the variations in the fuel and deliver to the burner a constant oil flow of varying



SECTION THROUGH FUEL REGULATING VALVE

viscosity and only a sufficient quantity to secure proper combustion. The Rigby fuel-regulating valve, manufactured by Bailey-Lewis, Inc., 406 Bakewell Bldg., Pittsburgh, Pa., is designed for this purpose.

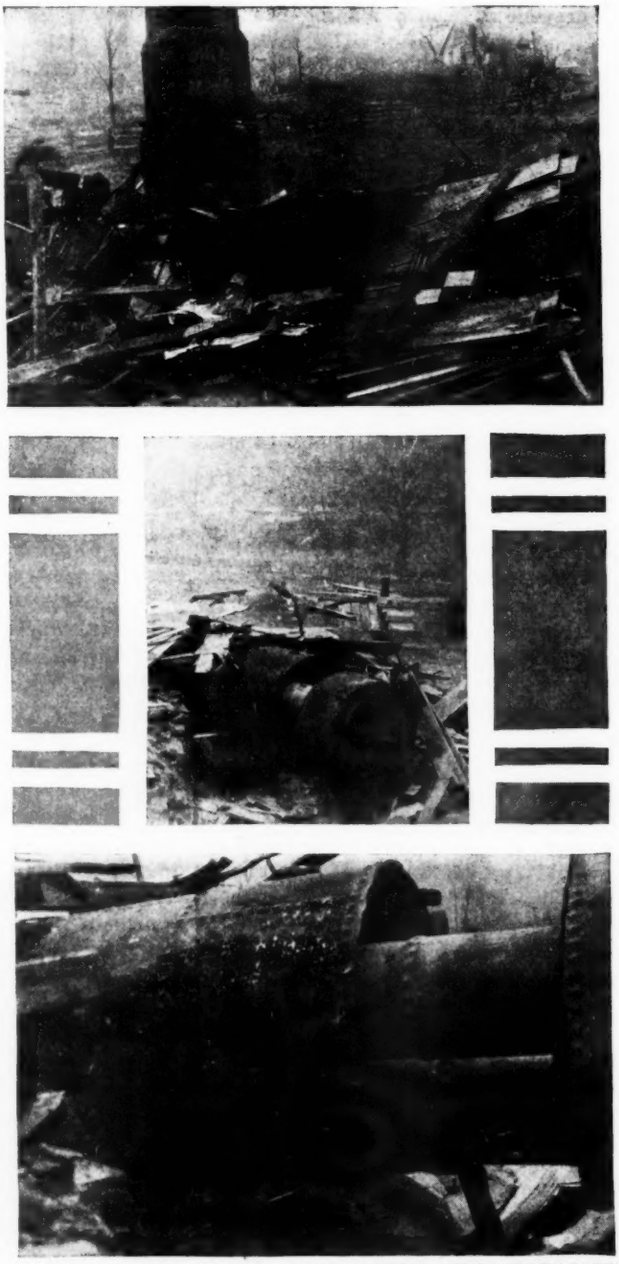
The fuel enters through the pipe *A* and passes down through the stop cock *B*, where any sediment or heavy particles settle; the fusel then passes through a triangular opening in the valve seat *C* to the nozzle or burner.

The distinguishing feature of the valve is the triangular aperture in the valve seat beveled back from the face, and a sliding, shearing valve running in a groove cut in the face of the seat. The valve slides across the triangular opening, which is 1 in. long by $\frac{1}{8}$ in. wide, at its widest part. This movement regulates the flow of oil by opening and closing the aperture. If sediment should lodge in the opening of the seat, it can be cleaned out by turning the handle, thus closing the valve. The valve stem is threaded so that one complete turn of the handle moves the valve $\frac{1}{16}$ in. The trap *D* can be cleaned without stopping the flow of fuel through the valve by turning the stop cock *B* and removing the plug in the bottom. A locknut arrangement makes it possible to set the device for any required quantity of fuel.

A Case with a Moral

The boiler shown in the illustration (or rather what was left of it) was about fifty years old and had never been inspected by either an insurance company or a state inspector. It was used occasionally for auxiliary power when the water was low, in a flour mill in Ohio, and its explosion caused the death of the owner and a property damage of about five thousand dollars. The boiler was of the two-flue type, 24 ft. long, 40 in. in diameter, of iron, originally about one-quarter inch thick, and made with a single lap joint. The shell was constructed of 30-in. courses and the flues, 15 in. in diameter, of two-foot courses.

As shown in the illustration the second course of the boiler was torn entirely away, and inspection showed that the plates of this course were wasted away, by general pitting and corrosion, to approximately one thirty-second of an inch thickness. Undoubtedly, had



ABOVE: THE FLOUR MILL AFTER THE EXPLOSION. CENTER: WHAT WAS LEFT OF THE BOILER. BELOW: CLOSE-UP, SHOWING WHERE THE SECOND COURSE HAD BEEN

this boiler been properly inspected in accordance with the Ohio Boiler Inspection Law, the accident, with its resulting loss of life and property, would not have happened.

EDITORIALS

Allowable Temperature Rise for Motors

DURING recent years there has been considerable discussion on the advisability of designing motors to operate at a fifty-degree, centigrade, rise instead of forty, which has been the standard for many years. It is obvious that a motor with a fifty-degree rise can be designed and built cheaper than one of the same horsepower and speed with a forty-degree rise. As every operating man knows, the first cost is of small consequence if the maintenance costs can be kept low and the motor made to give continuous service. Apparently, it is right here that, as far as the user is concerned, is to be found the answer to the question, Will the fifty-degree rise machine be just as reliable in service as the forty-degree machine? If it cannot meet this requirement, then the saving in first cost is of little consequence, since any increase in maintenance cost in the fifty-degree rise motor over the forty-degree type would more than offset any reduction in cost that might be obtained by operating at higher temperatures. A one-sided economy generally results in expense, therefore it is essential that in the selection of motors all the factors entering into the problem be considered.

In an article in this issue, "Allowable Temperature Rise for Motors," H. M. Phillips discusses this subject at considerable length. Although Mr. Phillips has given a very broad viewpoint of this matter over which there has been so much agitation and has drawn a conclusion not favorable to the fifty-degree rise machine, there is one feature that he has apparently overlooked, a feature of particular importance to the purchaser—the effects of temperature on commutation. In an alternating-current motor the chief concern with regard to temperature is to keep this at a value that will not cause the insulation to deteriorate. However, in a direct-current motor it is not alone a question of insulation deterioration, but also commutation. As long as the temperature of the commutator is maintained low, the brushes retain their lubricating qualities and the wear on both brushes and commutator is small, and under such conditions, in well designed machines, commutator and brush troubles are few. Machines have been known to operate for years under the conditions mentioned, with practically no wear of the commutator or brushes. But where the temperature of the commutator and brushes is allowed to become high, the brushes lose their lubricating qualities, begin to chatter and in many cases cause no end of trouble. Therefore, although insulation may be the factor that limits the temperature of an alternating-current motor, conditions existing at the commutator of a direct-current machine may be of equal or greater importance.

A large percentage of the ills of direct-current machines has always existed at the commutator, and it has taken many years of improvement in design to avoid these to the extent where a well-designed machine is satisfactory. If an increase in temperature will result in bringing back any of the commutator difficulties of the past, then a reduction in size and cost of the motor by operating at ten degrees higher temperature is not very attractive to the purchaser of such equipment.

One of the arguments advanced for a justification of the fifty-degree rise motor is that a large percentage of motors in service are being operated underloaded. While underloaded motors are a serious factor in alternating-current circuits' operation, with direct-current motors the same argument does not exist. Instead of a campaign for higher temperature rating of motors, would not more be accomplished by a movement by all parties concerned for having motors loaded nearer to their capacity, a study to be made so that more accurate information may be available for applying the motor to various loads? In this way, for a given amount of material put in motors in general, a higher rating would be obtained and the same end accomplished as with the higher rating. Furthermore, by raising the load factor, motors in general will operate at a more uniform temperature, and remain within forty-degree temperature rise.

The investigation into the general subject of temperature rise in rotating electric machines being carried out by the American Standards Committee and the American Institute of Electrical Engineers will be looked forward to with much interest. After all is said and done, the purchaser's chief interest is in obtaining a motor that will operate with a minimum of interruptions to service and that can be installed at a reasonable cost. The forty-degree rise motor does this, and if it can be accomplished by a fifty-degree rise machine under all conditions, then a distinct advance has been made. However, there is apparently considerable doubt on this point.

A Buyer's Market in Coal

DURING the last few weeks the bituminous coal situation has improved, and prices are declining. Looking at the situation from the consumer's point of view, conditions have so switched around that tendencies are toward a buyer's rather than a seller's market.

Government records show that from the middle of September through December the average production of bituminous coal was well over twelve million net tons a week. Continuation at this rate would mean an annual production of 624 million net tons. These data show that it is possible to produce this much coal with the railroad equipment and the labor conditions as they have been during the interval mentioned. Going back for a few years, statistics show that the productions of coal in net tons for the first 299 days of each year were as follows: 1917, 536,288,000; 1918, 566,349,000; 1919, 441,592,000; 1920, 537,555,000. These comparative figures in conjunction with a mild winter to date and a slowing down of industry would indicate that competition in the coal field should be keen throughout the new year.

During the past several years a number of new coal operations have been opened up. In the future only

those will continue to operate that can produce coal of a salable nature. The proper standard must be maintained, and preparations that will affect the quality and sizing of coal must be strictly adhered to.

With conditions shaping themselves as they are, the time is at hand for the consumer to exert his energies in taking advantage of the situation by giving his coal purchasers and the burning of the coal the proper attention. There should be no difficulty in securing the coal that will give the best results in his particular plant, and he should be able to buy it on its merits.

During the war and for a long time after consumers were compelled to accept coal regardless of preparation and quality. The experience they have had should teach them that the future deliveries of coal should be safeguarded and that good buying requires careful choosing and assurance that the quality and preparation are up to the standards desired.

Equity must always exist between the buyer and seller of coal, and to this end coal contracts must be drawn. There is no equity in a coal contract that is too drastic. The buyer and seller must enter into an agreement where fair play is predominant.

As it seems certain that competition will prevail again, the consumer should make ready to resume his old privilege of picking and choosing. He should determine what coal is best adapted to his particular plant conditions and then make sure that deliveries are up to standard.

Policies of Engineering Societies

THE requirements for admission to the Institution of Civil Engineers, which are typical of those of British Engineering Societies, will afford members of our engineering societies considerable surprise and some edification; and it is probable that the application of similar statutes on this side of the Atlantic would woefully deplete our prosperous membership lists.

These requirements include a suitable general education covering the humanities and general sciences, a suitable scientific knowledge applicable to engineering work, and a suitable knowledge of a foreign language; qualifications in these lines to be determined by examinations. Practical training comprising two to three years of apprenticeship under an engineer of standing and one to three years of practical experience in engineering are also required.

The policy of our societies, on the other hand, has been to accept a candidate's practical record as a measure of his intellectual fitness, and to grade their members in accordance with the scope and length of their practical experience. In this way less experienced candidates and those who have had less educational advantages are not excluded, and may profit by contact with prominent engineers in the various branches of the profession, while experience and achievement are given a certain authority and prestige by the grading system.

There are also several grades of members in the British society, but the strict entrance examinations probably bar the upper grades to all but those who have "come up from the ranks" within the Institution; for any man whose practical record would admit him to the upper grades has long since lost the examination "habit." The Institution therefore appears as a hierarchy in which members move up automatically as their experience and achievement become greater, and entrance into which is forbidden to all those whose education, general or technical, is not above the average. In reality, it is an engineers' guild, with a strong esprit de corps, and its very exclusiveness is a guarantee to the proficiency of its members in the profession.

Our societies, on the other hand, are essentially educational institutions purporting to give anyone having a vital interest in engineering a chance to broaden his education and viewpoint.

The difference in policies is one of absorbing interest and exists to a certain degree in most phases of public life, between ourselves and all the European countries. Our tendency is to raise the intellectual level of the people as a whole; the European principle is to foster an intellectual elite with which to leaven the masses.

As usual in such cases, the correct solution may be expected to lie somewhere between the two and institutions of both types have their uses. No one will question the value of societies such as ours, which through increasing attention to problems of economic and industrial nature tend to raise the prestige of the whole engineering profession in the eyes of the public. On the other hand, no one will question the importance of a body of intellectual leaders or fail to recognize that we are deficient in this respect. An institution like the British society is valuable in many ways, as a reservoir of highly skilled engineers, as a co-ordinating body to keep leaders of engineering work in close touch with one another, and as an educational body for the formation of new leaders.

Obsolescence of Diesel Engine

ENGINEERS will recall how, a few years ago, a number of magnificent Corliss engines installed in a New York power station were discarded, being replaced by steam turbines. These engines were in perfect operating condition and were probably the most efficient reciprocating steam engines built up to that time. The corporation could junk such machinery because of greater efficiency of the steam turbine. The saving secured through the latter machines was ample to cover the replacement cost in a comparatively short time.

In designing a new power station, the fact that more efficient types of prime movers will quite likely appear before the plant is worn out must be considered. This depreciation in comparative efficiency in the case of the Diesel engine need not be considered. There is little, if any, probability of a more efficient prime mover being made a commercial success. Even the gas turbine fails to show a higher over-all efficiency. That the Diesel itself will become more efficient is doubtful. This engine has been in commercial use since 1900. In the course of these twenty years the fuel consumption per brake horsepower has decreased from 0.425 to 0.38, representing a gain in efficiency of, roughly, ten per cent. About the only chance of any additional gain lies in an improvement in the mechanical efficiency.

Diesel engines have another interesting feature, in that the thermal efficiency is practically constant during the life of the machine. The decrease in efficiency, provided the cylinder compression is maintained, will not exceed ten per cent in fifteen years. This has been proved by several old machines which were tested both when new and after years of service.

CORRESPONDENCE

Unbalanced Throttle Valves a Failure on Large Engine Stops

To those of us who must be around large high-powered steam engines driving heavy machinery and who are familiar with the dangers incident to the failure of the governing mechanism pertaining thereto, it would appear that no more commendable pursuit could be engaged in than in perfecting any device that will add to or in any way aid in promoting safety to life and property from disastrous explosions and runaways. The object of this article is not, by any means, to "knock" any device of this kind, but to point out defects as they appear to the writer and make recommendations for the betterment of such devices.

Ordinary automatic steam-engine stops are usually actuated by a system of weights, which, when tripped by an electrical device, short-circuited by overspeeding, or tripped by hand, release the weights, and they in turn fall, driving a windlass which closes the throttle by means of a sprocket chain.

The point I wish to bring out is that an unbalanced throttle valve is a failure for this purpose except on comparatively small engines. I witnessed a runaway of a large Corliss engine a short time ago, which probably would have resulted disastrously had it not been for the fact that I was within ten feet of the throttle and was able to close it before any damage was done.

The cause of the runaway, as we afterward determined, was that the governor driving pulley, which was bolted in two halves on the 22-in. crankshaft, had become loose, the three locking set bolts having worked out slightly and the pulley, which was 42 in. in diameter, was turning on the shaft, although it did not stop entirely owing to the friction between the pulley and the mainshaft. If it had stopped the safety blocks on the valve gear would have prevented the valves from opening after the engine had first speeded up and the governor balls had fallen from gravity, and the engine would have stopped. But the friction between the mainshaft and the governor pulley kept it turning fast enough to clear the safety blocks, and the outfit was turning at a terrific speed before we got the throttle closed.

The automatic engine stop tripped off as it should have and probably did all that the manufacturers claimed it would do. The throttle valve went part way shut and slowed down and was practically at a standstill, only moving slightly with each pulsation of the engine until we finished the operation by hand.

This throttle valve worked perfectly free, and had metallic packing at the stuffing box, which did not bind, and it was in first-class condition in every way. It is the custom to test these stops out each day in the following manner: If the engine is in actual operation one man stands at the throttle and prevents it from going entirely shut, while another man pushes the plug and "sets 'er off." If the engine is not in operation, the valves are unhooked so that the inlet valves are closed and the throttle valve opened wide. The plug is then pushed, and the throttle valve is allowed to go to its seat. This latter method is most desirable as it permits us to weight the machine so that the valve will go shut just hard enough to prevent injury to the valve.

It must be remembered that in this case the pressure is balanced, that is, there is the same pressure on both sides of the disc of the valve. The throttle valve in our case is a 10-in. ordinary globe valve.

The reason the valve did not close when the engine overspeeded and released the automatic device is as follows: As the throttle valve has a 10-in. disc there is 78.54 sq.in. of effective area, and as we carry 140 lb. pressure on the line above the throttle there is $78.54 \times 140 = 10{,}955.6$ lb. pressure on the steam side of this disc for it to shut against. On the back side of the disc, with the valve partly shut, the balancing pressure is considerably less—probably it is expanded to something like the m.e.p. under ordinary conditions, which in our case runs around 64 lb., which would equal 5,026.55, or a little over 5,000 lb. on the back side of the disk and over 10,000 lb. on the front side for it to shut against. Of course these pressures are by no means exact, but they will serve to illustrate the point I am trying to bring out—that an engine stop on an engine of large size, to be dependable, if it depends upon the actual closing of the throttle to perform its functions, should be provided with a balanced throttle valve.

To controvert this argument the point may be brought up that we could weight the machine heavily enough to shut the valve against this difference in pressure. So we could, but if we did it would require so much weight that when it was tested out as outlined in the foregoing, with the engine not in operation, we would either punch the seat out of the valve or push the bonnet off, and something would be liable to happen.

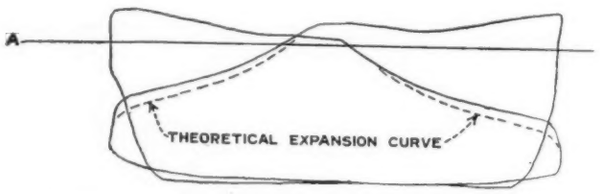
When engine-stop builders can see this matter in the same light that I do—that is, that an unbalanced valve of the size of the one under discussion is a failure—and equip all such stops with balanced valves, then, and not until then, will we have automatic stops that will perform the function allotted to them, under any reasonable conditions.

GEORGE VAN VLACK.

Rochester, N. Y.

Diagram Did Not Indicate Faulty Valve Setting

In the plant where I am employed there is a steam-driven cross-compound condensing four-stage air compressor of 1,500 cu.ft. capacity. Since coming to the plant I have been entirely satisfied with the performance of this unit, as the indicator cards from both cylinders showed that the valve gear, which was of the double-eccentric Corliss type, releasing on the high-pressure



DIAGRAMS DO NOT INDICATE LEAKING VALVE

cylinder and non-releasing on the low-pressure cylinder, was functioning very well.

However, while testing the low-pressure cylinder for a leaky piston, I placed the low-pressure crank at about one-quarter of the inward stroke, thus making the cylinder take steam on the crank end and exhaust on the head end. On turning on steam, by means of the starting bypass, there was a strong rush of steam from the head-end indicator cock. This naturally led me to believe that the piston was leaking badly, but on plotting the theoretical expansion curve on the indicator card, it showed the toe of the actual curve rising somewhat above the theoretical, a fact that would point to leaky inlet valves rather than a leaky piston. The inlet valves tested tight, however, on being placed in mid-position, so I had to look for the leak elsewhere.

Ultimately, I found it by removing the valve covers and observing the motion of the valves while the valve gear was worked by hand. The inlet valves were double-ported, and the head-end one swung so far to the fully closed position that it was really opening for the second time; that is, the back edge of the valve was opening into the back edge of the steam port.

The amount of opening was about ¾ in., and as the exhaust valve for this end was wide open, it allowed the steam to blow straight through from the receiver to the condenser, with a difference in pressure of 14 lb. per sq.in. between the two. The fact of the exhaust valve being wide open apparently caused the defect to show no rise of pressure on the exhaust line of the diagram.

The indicator diagram is our only means of measuring the power and efficient working of this engine, and while the engine-room staff were relying on it and congratulating themselves on the nice diagrams they were getting, there were really quite a number of B.t.u.'s leaking past unobserved.

Needless to say, the valve gear was adjusted at the first opportunity, and I notice the receiver pressure is now a little higher and does not pulsate so severely as it used to. The loss in this case was probably not great enough to show any noticeable difference in the power of the engine, but in these days, with coal so high in price, one wants to convert all the energy in the steam into useful work that one possibly can. What struck me as rather strange was that the valve gear could be so far out of adjustment without affecting the other events of the cycle, but the wristplate action of the non-releasing gear accounts for it. The variation between the actual and the theoretical curves is probably due partly to a slight error in plotting the curve and partly to re-evaporation taking place in the cylinder.

THOMAS C. PORTEOUS.

Michel, B. C., Canada.

Filing Useful Data

There are various ways of filing magazine articles, and no doubt many are using my system, or one with improvements, but this is for the fellow who has no method and wants to save some of the useful information that comes weekly in each copy of *Power*.

Copies filed away whole soon make a system heavy and bulky, and it generally happens that there are only a few articles in each issue that the reader cares to keep in his file. A scrapbook is a good place to lose articles, because it is rather difficult to index. The best method is the one that is the most flexible and simple—the one to which anyone can refer and find the article or data wanted.

Material necessary to file and index clippings should consist of a drawer 10½ in. high and 12 in. wide in a correspondence file; a number of 1-in. expansion folders of correspondence size, and a smaller drawer complete with A to Z index cards (about 4 by 6 in.) and several hundred plain cards. Suppose that the first subject to be saved is entitled "Compiling Useful Data." With a sharp knife cut this sheet from the magazine and mark the top with a large figure 1. Next cross-index on the 4 x 6-in. cards under as many heads as seems desirable. Let us say three: Compiling Useful Data; Data, Compiling Useful; and Information, Compiling Useful Data.

The first card entitled "Compiling Useful Data" has

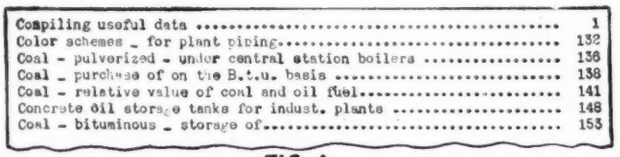

Compiling useful data 1
Color schemes _ for plant piping..... 132
Coal - pulverized - under central station boilers 136
Coal _ purchase of on the B.t.u. basis 138
Coal - relative value of coal and oil fuel..... 141
Concrete oil storage tanks for indust. plants 148
Coal - bituminous _ storage of..... 153

FIG. 1

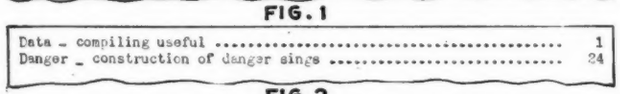


FIG. 2

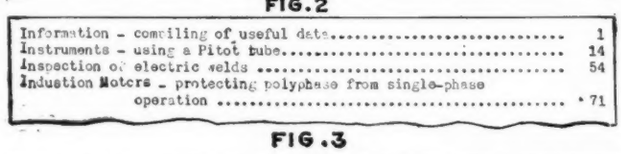

Information - compiling of useful data..... 1
Instruments - using a Pitot tube..... 14
Inspection of electric welds 54
Induction Motors _ protecting polyphase from single-phase operation 71

FIG. 3

FIG. 1 TO 3. SHOWING METHOD OF INDEXING SUBJECTS

its own filing tab headed "Co" as shown in Fig. 1, and is filed back of the index card *C*.

Right here it would be well to explain how the alphabetical index is subdivided so as to aid in finding the cards. As required, cards filed under *C* are made out headed as *Ca, Cb, Cc, Cd, Ce,* etc. So we will find *Co* coming right after *Cn*. If the card is removed, this heading tells the correct place to return it.

Therefore the second card, entitled "Data, Compiling Useful," is entered on a card headed *Da* and is filed under the index card *D*. This card *Da* naturally comes

first in the *D* section and cards headed *Db* will come next (see Fig. 2). The third card, Information, Compiling Useful Data, will be entered on an *In* card, filed under *I* and coming after the *Im* cards (see Fig. 3).

As will be noted in Figs. 1, 2 and 3, the number of the clipping, 1, appears on each card after the title.

Should the second clipping be entitled "The World's Largest Boilers," the method is this: Cut the sheet

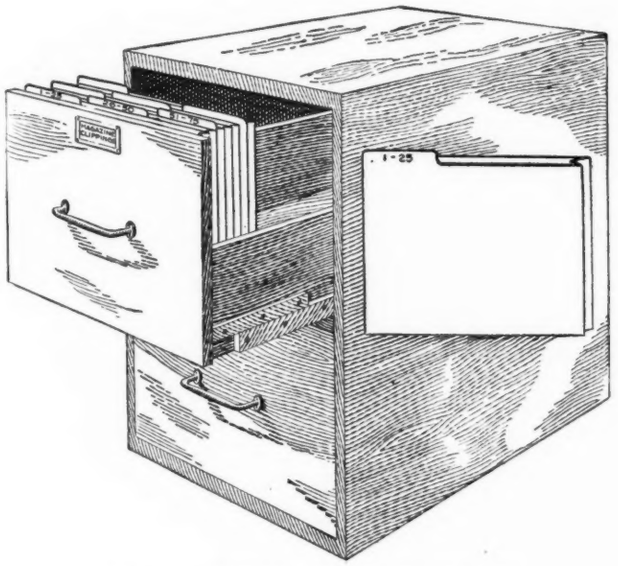


FIG. 4. FILING CABINET AND FOLDER

from the magazine, number the sheet at the top with a large figure 2, make out a *Wo* card under "World's Largest Boilers—2, and file under *W*. Then another card under *Bo* entitled Boilers—The World's Largest—2, and file under *B*. One may want a card under *P* subdivided to *Po* and headed Power Plants and here you will find Power Plants—The World's Largest Boilers —2.

If the subject to be clipped is made up of several sheets, pin them together or use paper clips. The expansion folders will conveniently hold 25 clippings and should be indexed as shown in Fig. 4. The first folder will contain clippings numbered from 1 to 25 consecutively, the second folder will contain clippings numbered from 26 to 50 and so on as fast as the clippings come.

Suppose we are looking for information on The Storage of Bituminous Coal. We naturally would look for this article under the heading Coal. First turn to the card index under *C* and subdivided to *Co* and find the title, also the number *153* (see Fig. 1), which tells us that this article is in the 151-175 series and is filed as number 153.

The index cards can be made out in longhand or printed with a pen, but it is preferable to have them typewritten.

If care is taken in selecting the clipping, a valuabl collection will soon result which has many advantages. It is not bulky, an article is easily and quickly found and can as easily be returned to its correct place in the file. The cross-indexing can be done by any clerk, and the more a subject is cross-indexed the more readily can it be found.

A. F. GRAVES.

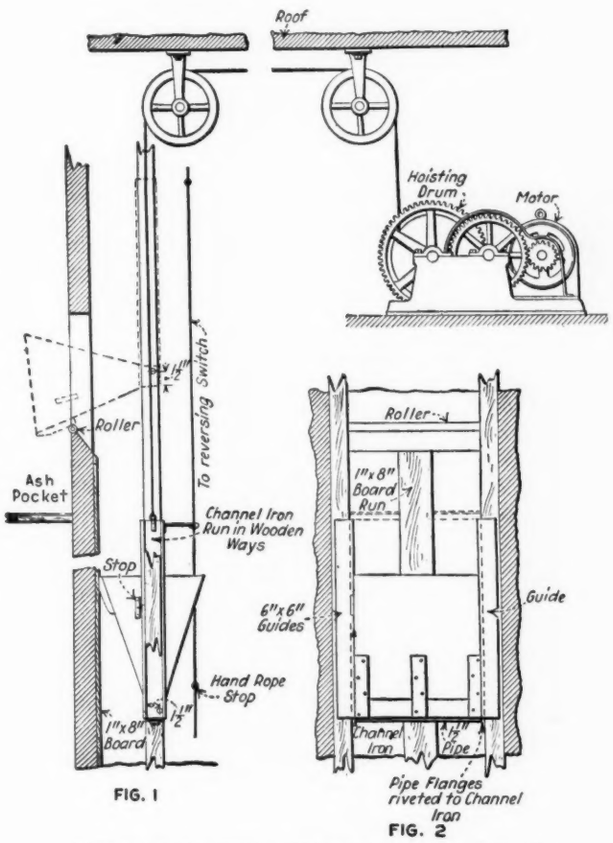
Cleveland, Ohio.

Home-Made Ash Hoist

We have two 400-hp. water-tube boilers that are used for heating purposes. Trouble was had in getting rid of the ashes until we rigged up an ash pocket and bucket as shown by the sketch. It is outside the boiler-room wall, and the ash pocket is built of 2-in. plank, lined with sheet metal, and holds about 10 tons.

The V-shaped bucket is made of ⅞-in. boards and lined with sheet metal. As will be seen, the center of the bucket is set about 1½ in. off the center of pull. This causes it to hug the wall until the opening to the ash pocket is reached, when it slides over as shown by the dotted lines and dumps its contents, returning again when the machine is reversed. A 1 by 8-in. board is secured to the wall for the reinforcement piece on the bucket to rub against.

The hoisting machine is a second-hand one equipped with machine limits. The motor and reversing switch we had on hand. The ash bucket will hold about three wheelbarrow loads of ashes and travels about 50 ft. per minute. The top of the bucket comes down to the floor line so that the ashes can be dumped from the wheelbarrow into the bucket. Since its installation we



DETAILS OF THE HOME-MADE ASH HOIST

seldom have to hire a truck to carry the ashes to the ash dump. The teamsters around the city watch the ash pocket when they need ashes for filling purposes and they can load up in a few minutes. It also does away with ash cans. We had to keep about forty on hand, which cost about five dollars apiece. It will not take long to pay for itself, as the work was done by the men around the plant.

THOMAS SHEEHAN.

Springfield, Mass.

Why Does a Leaky Compressor Valve Get Hot?

The question asked in *Power* by Donald McFee (page 795, Nov. 16, 1920) is an interesting one and seems to invite, or at least permits, something more than a simple, straight, categorical answer to the specific inquiry, if, indeed, such an answer were possible, which, as will appear, it is not.

In connection with the consideration of the question presented it will be convenient to call attention to more details of air-compressing practice that are essential to safe and satisfactory operation. There may be little of novelty in the matter presented, but much of it requires to be repeated over and over again for the promotion of reasonable observance in practice. And it may as well be observed that some of the operating conditions in the case of Mr. McFee's compressor are not just as they should be, as is evidenced by the occurrence—the most unusual occurrence, as would appear—of "leaky" discharge valves.

As a matter of fact it is not a leaky valve about which he inquires at all, but a valve that has ceased to function on account of being stuck, presumably in the wide open position, so that a quite appreciable portion of the air compressed per stroke is not retained by the prompt closing of the valve.

The cause of a valve sticking, which of course is of the poppet type, is an accumulation of oil residuum, hard and gummy, baked or burnt upon the guiding surfaces of the valve; and it is reasonably certain that the superfluous oil would not be there to make the trouble if there had not been too much oil fed to the cylinders.

The most serious trouble and expense, not to say danger, in connection with the operating of air compressors seem to have to do with the oil used, and this sticking of a valve is by no means its only manifestation. In fact the valve trouble acts incidentally as more or less of a check on the reckless dosing of the machine. It is a curious thing that the complaint always is about too much oil and never about too little. It would be well if we were more frequently reminded of the records of oil consumption in the cases where no objectionable consequences are attributable to its presence.

In the pages of *Power* as far back as 1911 there is an official record of a month's running of the compressors on the Panama Canal, in which it appears, after boiling down, that at Rio Grande a gallon of lubricating oil was used in the air cylinders for 3,360,124 cu.ft. of free air compressed; at Empire, for 4,317,716 cu.ft., and at Los Cascadas, for 5,163,936 cu.ft.

There is another record elsewhere, a couple of years later, in which the oil consumption was less than one-third of the best of the foregoing figures. This authenticated report was of a compressor that had been running for five years, twenty-four hours a day, in the power house of the Nevada Consolidated Copper Co. and compressing 16,000,000 cu.ft. of free air per gallon of lubricant used.

Besides the quantity of oil used, the quality also makes a great difference; but this is not necessary to discuss here. Some theorizing and much experience in the using of different oils are gradually leading, at least we may hope so, to the survival in practice of the oil that proves most fit.

We have now got so far along that valves are becoming quite common which cannot be made to stick in the wide-open position, or even partly open or anywhere else by accumulations of burnt oil, because the oil is conspicuous by its absence. Valves that operate between guiding surfaces, as, for instance, those of the poppet types and especially in a horizontal position, presumably require more or less lubrication, and in administering the oil these are thought of as well as the cylinder surfaces, the pistons and the stuffing boxes, but plate valves do not call for lubrication, and if a little oil is carried along by the air when passing them none of it has any occasion to stop there.

There is no reason to suppose that any plate valve ever becomes appreciably hotter than its companions, but if such a thing could possibly happen it would not be discoverable outside the machine. A heated poppet valve, however, must immediately reveal its condition by the overheating of the projecting cap or case. As the valve is heated by the air that is in contact with it, it can in no case become hotter than the air.

As to why any one of the valves should get hotter than the rest, or as to how its abnormal temperature can be evidence of its failure to operate, would seem to admit of a simple explanation. We have only to think of the difference in cooling or heating effect of air actively in motion from air that is stagnant and inert. If you have a spoonful of boiling hot soup that you are in a hurry to taste, you blow on it half a dozen breaths and it quickly cools down to the point of comfortable deglutition, although the temperature of your breath is somewhat higher than that of the atmospheric air with which the soup is already in contact. We may assume that air acts in precisely the same way in the heating of an object against which it rushes, or upon which it impinges, as it does in cooling an object when the temperatures are reversed. The body of a poppet discharge valve, when it is working correctly, is in contact with the air at its highest temperature and with rushing force to it only during the period of actual delivery of the fully compressed air, or less than a quarter of each alternate compressing stroke, or less than an eighth of the total time. A valve that is stuck wide open, however, is in the rush of the hottest air for practically the whole of both strokes; we cannot wonder at the difference in the result, and it is not worth while to go into the details any further.

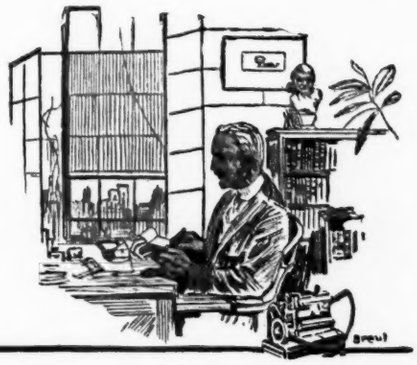
New York City. FRANK RICHARDS.

Referring to the explanation given by G. M. Matthews, page 949, of the Dec. 14, 1920, issue, where he states that heating of a leaky compressor valve is caused by friction or wiredrawing of the escaping air, I take issue with his answer.

I have observed that leaky discharge valves on air compressors will not only cause the valve to heat, but will cause overheating of the entire piston and cylinder, also the receiver. A leaky inlet valve will diminish the power or capacity, but it has hardly any tendency toward overheating. A leaky discharge valve causes heating because the air is first heated by the compression of the piston, is then forced into the discharge pipe or receiver, and on the suction stroke this hot air or a portion of it escapes back into the cylinder past the leaky valve and is again and again compressed and with increasing temperature. The friction may and doubtless does generate some heat, but the accumulated heat of compression is the main cause of the overheating. JOHN A. WALKER.

Stroud, Okla.

INQUIRIES OF GENERAL INTEREST

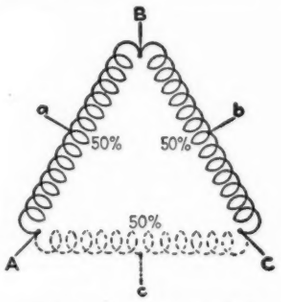


Intensity of Pressure Exerted by Water and Mercury—What would be the indication of a pressure gage placed at the foot of a 6-in. standpipe 100 ft. high when the pipe is filled with water and when filled with mercury? J. J. S.

When the liquids are at the temperature of 62 deg. F., the intensity of pressure of a column of water 1 ft. high is 0.433 lb. per sq.in., and that of a column of mercury 1 ft. high is 5.892 lb. per sq.in. A pressure gage so placed that the center of the gage is level with the foot of the water column 100 ft. high would indicate $0.433 \times 100 = 43.3$ lb. per sq.in., and the gage so connected that its center would be level with the foot of the mercury column 100 ft. high would indicate $5.892 \times 100 = 589.2$ lb. pressure per square inch. In each case the pressure shown by the gage would depend on the height of the liquid and would be independent of the diameter of the standpipe.

Voltage Taps on Three-phase Transformer—Why is one-half line voltage obtained between 50 per cent taps on a delta-connected three-phase transformer, when there are the same number of turns between the 50 per cent taps as between the full voltage terminals? M. P.

Consider one leg of the transformer, say *AC*, removed. We now have an open-delta connection. The voltage *AC*



is the resultant of voltages *AB* and *BC*, yet it is equal to each of these and not to their sum, because they are 120 deg. out of phase. The voltage between 50 per cent taps is the resultant of half of the voltages *AB* and *BC* and is therefore equal to one-half of *AC*, or half of the line voltage.

Shortest Economical Cutoff for Plain D Slide Valve—Why cannot a D slide-valve engine economically cut earlier than one-half stroke? C. J. Y.

In a slide-valve engine cutoff before the end of the stroke is obtained by setting the eccentric more than 90 deg. in advance of the crank, and that hastens all of the valve events. The lead must be corrected by adding lap to the valve. There is then less valve opening and also slower motion of the valve at the points of opening and closing, because those events occur when the eccentric is nearer its dead center, and therefore shortening of the cutoff is accompanied by wiredrawing the steam and there is realization of considerably less than steam-chest pressure, even at the beginning of the stroke. Hastening of the release is accompanied by hastening closure of the exhaust. If the release is delayed by adding lap to the exhaust edge of the valve, less exhaust opening is obtained, the greater back pressure is further increased by earlier closure of the exhaust, and the resulting compression may be so excessive as to force the valve from its seat and thus permit leakage of steam from the steam chest directly to the exhaust outlet of the engine. These considerations affecting the action of the plain D slide valve have established a limit to which it may be economically used. It is sometimes employed for cutoff at one-half, but as a rule with a fixed eccentric, not earlier that five-eighths stroke.

Superheated Steam for Reciprocating Engines—What benefit is derived from supplying superheated steam to a reciprocating engine and what degree of superheating is advantageous? T. B. S.

The main benefit derived from supplying a reciprocating engine with superheated steam is to counteract cylinder condensation and assure the presence of dry steam at the time cutoff occurs; and there is additional gain in engine efficiency from superheating the steam to such a high degree that the steam will be superheated during the exhaust.

The degree of superheating necessary for insuring dry steam at cutoff depends on the conditions. Ordinarily, this will be obtained by having the steam, as delivered at the engine, superheated about 75 deg. above the temperature of dry saturated steam of the given pressure; and to avoid any cylinder condensation from admission to exhaust usually requires about 150 deg. of initial superheating. The over-all economy of superheating the steam depends on the plant-operating conditions.

Laying up Fire-Tube Boilers for a Long Time.—We have a number of stationary fire-tube boilers of different types that may be laid up out of service for a long time. What is the best method of preventing their deterioration? W. L. C.

When a boiler is laid up out of service, it should be thoroughly cleaned inside and outside and protected from moisture. After thoroughly cleaning the inside, the boiler should be filled nearly full with clean water and then filled to overflowing with a low grade of mineral oil. The water then may be drawn off, leaving all parts of the interior coated with oil. Any water left in depressions then should be driven off with a light wood fire. As an additional precaution against rusting, place a small quantity of unslacked lime in the boiler before closing it up. Thoroughly clean out fire tubes and swab them with oil, paint the outside of flue sheets and plug tube ends with waste. For a locomotive type of boiler, or any but a boiler set in brick work, thoroughly clean the exterior and give it a coat of asphalt or red-lead paint. Boilers that are bricked-in usually are protected from the weather, and their exterior surfaces will not need any further care than to protect them from moisture. Seal fire and ashpit doors tight and seal dampers with asbestos, cotton wool or other convenient filling for crevices and, if practicable, disconnect them from chimneys so that there will be no circulation of air to deposit moisture. To remove oil from the interior of a boiler that has been laid up with an internal coating of oil, fill the boiler nearly fill of water, to which add about 10 lb. of soda ash for a boiler rated 50 to 150 hp. and, after boiling for about 10 hours over a slow fire, with 1 to 5 lb. gage pressure, thoroughly wash out the boiler and fittings.

Fuel Conservation*

By DAVID MOFFAT MYERS

SEVENTY-FIVE to one hundred million tons of coal could be saved annually in the United States in addition to a similar reduction in the consumption of other fuels, by the simple adoption of sound engineering principles in the use of fuel. Based on only 75,000,000 tons, the money saving would be $450,000,000 a year, or enough to pay nearly one-half the interest of our national war debt. The transportation of coal would be relieved to an extent equivalent to a million and a half 50-ton carloads per year, or 50 per cent more than the coal-carrying capacity of the Pennsylvania Railroad lines east of Pittsburgh. The services of 75,000 miners would be conserved, and the additional labor connected with the loading, transportation, unloading and firing of a million and a half less cars of coal per year would be eliminated. A common-sense engineering program of fuel conservation would save over four dollars per capita for every person in the United States annually.

All consumers of coal would benefit financially by a program of constructive conservation. During the war, by the adoption of very simple rules governing methods of operation alone in our power plants and on our railroads, an annual saving of 25,000,000 tons of coal a year was effected with the program in operation in twenty-five states for an average time of less than four months. It was impossible at that time, owing to conditions imposed by the war, to adopt measures affecting also the design or equipment connected with the use of fuel. A future program should include such measures.

Unnecessary Waste of Fuel

Conservation during the war was a rush job. Like other rush jobs it was neither thorough nor complete, but it had to be done in that way at that time. Now we have more time to think over the situation and lay plans for a thorough and complete job, and it is time that we were thinking over those plans. There is at present a huge and unnecessary waste of fuel in this country. The waste is everywhere. There is not an industrial plant in the country where 10 to 30 per cent saving of fuel might not be effected by common sense engineering. Some of the items relating to this waste are as follows:

1. Waste in the boiler plant, including the very large item of inefficient combustion of fuel under stationary and locomotive boilers.

2. Coal consumed in the old-fashioned beehive coke ovens represents 9.3 per cent of the total. Only 4.3 per cent is consumed in the byproduct coke ovens.

3. In domestic heating it is estimated that 12 per cent of the coal is used. Very large savings were made in this department during the war, and much more can be done by proper conservation methods. The psychological importance of emphasizing fuel economy in this field is evident, owing to the fact that it would deal with 20,000,000 people or householders, whereas by comparison, fuel conservation in the industries would deal with only 200,000 plant managements and those of the railroads.

4. Fuel is extravagantly wasted by the improper use of steam after its generation. For instance, by the use of

a. Inefficient prime movers.
b. Careless maintenance of power-consuming machinery.
c. Ill-advised installations, unsuited to the purpose they would fulfill.
d. Huge volumes of wasted exhaust steam expelled to the atmosphere or to condensers, and live steam used for heating without first developing its quota of energy.
e. Unnecessary use of live steam where exhaust steam with proper engineering would fully meet the requirements.
f. Badly designed and ill-kept transmission systems.

Of these forms of waste item (d) needs the greatest emphasis. Everyone knows steam is being wasted when he sees clouds of exhaust blowing out into the air, but how many peeple (not engineers) realize that our modern and highly efficient central stations are guilty of wasting some 80 per cent of the heat of the steam into the condenser, while at the same time, particularly during the heating season, hundreds of buildings and factories in the vicinity are burning thousands upon thousands of tons of coal for heating purposes, and that the owners of these would gladly dispense with their expensive heating plants if the central stations would sell them heat as well as power? The heat thus sold would be a byproduct of the power generated by the central station and could therefore be sold cheaply and at a good profit.

Each Private Plant Must Be Considered by Itself

The other side of the problem relates to the private plants, each of which must be diagnosed according to the merits of the case. Many industrial plants can utilize all the exhaust steam from their own power plants all the year round, and in such cases their power is merely a byproduct of their heating fuel. If they were to shut down their engines or turbines, they would still have to burn about 90 per cent of their former coal consumption, so that only 10 per cent of their engine water rate is chargeable to power. Such a plant, of course, produces its own power so cheaply that no central-station condensing power plant will ever be able to compete with it. Frequently, it would easily be able to generate more power than it could use without wasting any exhaust steam, under which circumstances it should be enabled to sell its surplus power to a central-station system. This would be highly beneficial economically, both to the central station and to the private plant. This represents the one extreme of conditions in the private plant.

The other extreme exists when the private plant has no use for heat and wastes all its exhaust to the atmosphere. Coal, and money too in many instances, would be saved if the owner shut down his engines and purchased power from a more efficient central plant. There are many stages between these two extremes. For instance, the private plant just mentioned, if the power requirements were sufficiently large, could afford to install modern equipment and make its own power more cheaply than it could buy it. Coal might not be saved over the plan of buying power from the central stations, but money would. A very common case is that of the private plant that can utilize all its exhaust heat during the heating months, but wastes it through the non-heating months. Such a plant should make its own power in cold weather and buy in warm weather.

Both Central Stations and Private Plants Are Wasteful

Fuel conservation can never be satisfied by the central power-plant idea alone; the privately owned plant is essential to economy, and each has its special and appropriate field of service. Neither, as they are operated today (in the average case) fulfills its duty, and the only solution is an adequate plan of co-operation between the two types of plants for the mutual advantage of both in the saving of money and for the advantage of the public in reducing the present enormous and needless waste of coal.

To sum up the matter, the underlying principles are these: All steam used for heating should be made to develop its quota of energy for useful consumption. Also exhaust steam from turbines or engines should never be wasted into the condenser when there is available an opportunity to apply it for heating for industrial or building purposes.

The need of a definite policy of fuel conservation is urgent. Natural gas, the most nearly ideal of all our natural fuels, today is practically gone. Inside of three years there will be no more available for industrial uses, and all because of our failure to demand a definite policy of conservation. We permitted, instead, a definite policy of waste.

*Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, New York, Dec. 7, 1920.

The next natural fuel to go will be oil. The supply in the United States it is estimated will be used and wasted out of existence in from twenty to thirty years. Our production is stated at one million barrels of crude oil a day, which is more than 60 per cent of the world's total output, but this is not enough for our present domestic consumption. The peak of production will be reached in a very few years, whereas the consumption is increasing steadily. That the expensive method of producing oil from the shale beds of Utah, Colorado, Wyoming and Nevada is being more and more brought to the attention of investors is an indication of the urgency of the oil situation. The writer submits to the engineering profession that, as one measure of oil conservation, fuel oil should not be burned under steam boilers for purely power-generating purposes, where its over-all efficiency is ordinarily not over 5 to 10 per cent. It would be entirely appropriate to allow its use in high-efficiency internal-combustion engines, with efficiencies ranging from 25 to 34 per cent. The United States Navy and certain process uses would be proper exceptions.

Our natural gas is practically gone. Our oil supply is vanishing rapidly and coal is the next fuel on the list. Anthracite will be the first to disappear and then bituminous coal, our last natural fuel resource.

Government Aid in Conservation

It is now the time to consider how the Government can assist in the conservation of coal and oil. It is the writer's personal opinion that coal and other natural fuels present a problem that so intimately concerns the welfare of all the people that it must equally concern the Government which represents the people, and that therefore until the general public through its Government takes action in the matter, there can never be any truly adequate solution of this problem. The mere financial incentive to stop the unnecessary waste of fuel is not strong enough to do the job, for the reason that the great bulk of coal and other fuels is consumed in industrial undertakings, wherein substantial profits are readily available without the trouble of economizing in the application of fuel. This fact may be strikingly realized through the statement of an authority that of the total cost of all the manufactured products of the country only 2 per cent is fuel cost.

The public at large does not yet fully realize the importance of fuel as a national issue, but the writer believes that even now it is coming slowly into such a realization. Therefore, although the time is not yet ripe for any radical step in this direction, we may and must look forward ultimately to a solution along these lines.

The public must be made to see how adversely it is affected by this great and uncontrolled waste of fuel so that Government co-operation and assistance will be demanded. This means that time will be necessary in which to educate the public as to the importance of fuel conservation as a national issue in order to secure the necessary interest by Congress and Government bureaus.

Finally, the writer wishes to offer for consideration and constructive criticism the following policy of fuel conservation to be adopted with the co-operation of the Government:

1. Regulation of quality of fuel.
2. Measures for prevention of flagrant waste of all fuels. The measures should apply to their production, preparation and transportation and finally consumption.
3. In the matter of transportation, zoning is productive of large economies.
4. Better means of coal storage are urgently needed to flatten out load curves at the mines, which are now overcapitalized and overequipped 40 per cent; the worst-run industry in the country, its influence is far-reaching in industrial and social problems.
5. Possibilities of conservation by the United States Bureau of Mines.
6. Great advantages to be secured by appointment of a resident engineer in each state, to keep in close touch with local industries and with a clearing house of information in Washington.
7. A body of citizens advisory to Bureau of Mines should assist in the planning and development of the conservation program. It should be representative of business men, engineers and citizens from various parts of the country.
8. Correct design of new power plants, and perhaps changing of power equipment in existing plants. It is unfair to the public to allow plant changes or new plants to be installed which will permanently waste fuel. Such a measure would mean reduced operating expense to the owner of the plant.
9. Government should encourage new inventions and investigation, leading to the economical use of fuel.
10. Better educational measures. Every technical school should have lecture courses on fuel conservation, more for the purpose of emphasizing its importance rather than from intensified and specific instruction. Educational courses for chief engineers and firemen. Examination for license in this profession. Provide throughout the country uniform examinations with corresponding certificates for operating engineers and firemen thus educated in steam and fuel and economics. Courses similar to those published by the National Association of Stationary Engineers, the Hartford Steam Boiler Insurance Co., Hays Combustion Course, etc., are very suggestive of what the writer has in mind, but there should be standardized Federal examinations for issuing of certificates.
11. Measures looking toward the development of low-temperature distillation of coal (and lignite) for the conservation of the immensely valuable byproducts which at present are wasted when raw coal is burned for steam making. The resulting smokeless carbonized coal would then become the boiler fuel of the future in proportion to the extent to which this byproduct industry could be economically developed.

Narrow Escape!

Joe, the oiler, got a bit absent-minded the other day and walked off the top of his ladder. Joe got a black eye, knocked out a couple of teeth and got shook up considerable, but fortunately, he wasn't hurt.

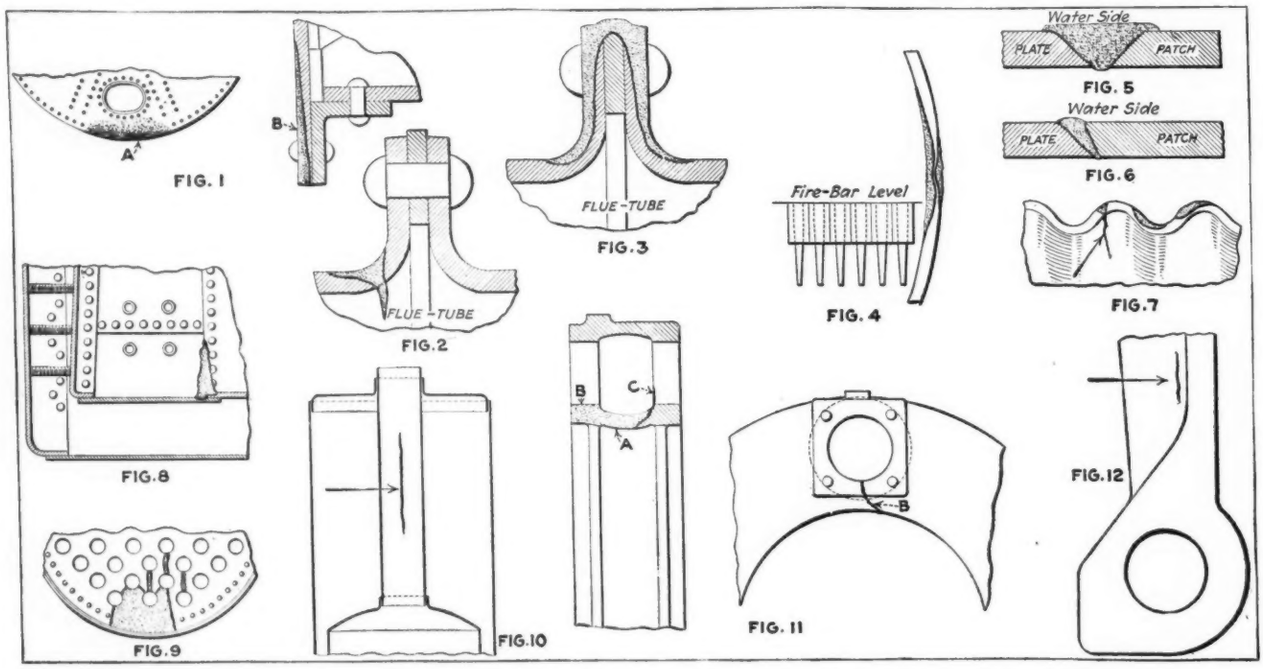
Examples of Welding Repairs to Boilers

IN ITS application to repair work autogenous welding offers an attractive field, and a considerable amount of such work is now done regularly with satisfactory results. However, there are limits beyond which, at present, it is not considered advisable to go in adopting this method of repairing defects in boilers and engines. The National Boiler and General Insurance Co., Ltd., Manchester, England, has recently issued a booklet, "Repairs to Boilers and Engines by Welding," the object of which is to inform its inspectors and the firms insuring their machinery under the company's policies, how far and for what kind of defect a repair by welding may be sanctioned. In the following is given an abstract from this booklet.

External Wasting of Lower Part of Front-End Plate—The lower part of the front-end plate of cylindrical boilers is often allowed to become badly wasted through contact with damp ashes and the wasting can be satisfactorily made good by welding. New metal is built up as indicated at chipping, and if the rivets have been removed new holes are drilled and the seam reriveted.

Wasting at Sides of Furnace Tubes—The first two rings of each furnace tube of a Lancashire boiler were found wasted on the fire side at each side of the bar level, as indicated in Fig. 4. It was decided to build up the wasted parts on the fire side by the oxyacetylene welding process. On completion of the process the boiler was hydraulically tested, but leakage occurred through the welded portion. On examining it on the water side, it was found that the plate had been drawn in, as indicated, during the operation of building up. Further repair was afterward effected by applying metal on the water side, and this made a satisfactory repair.

Pitting in Furnace Tubes—It is often found that furnace tubes are pitted externally over considerable areas, and when the pitting has not reached too great a depth the plates may be built up again by welding. Sometimes this



FIGS. 1 TO 12. PARTS OF BOILER ON WHICH REPAIRS HAVE BEEN MADE BY WELDING

A and *B*, Fig. 1, so as to restore the plate to its original thickness.

Grooving of Flat End Plates Over the Furnace Tubes—This class of defect, if not so extensive as to impair the safety of the boiler, may be repaired by filling in the grooving, but such proposals should be submitted for the chief engineer's consideration, as a repair by welding can be approved only in those cases where the grooving is confined to a few short lengths and where the end plate is not unduly stressed by insufficient breathing space being allowed in the design.

Broad Grooving in the Root of the Flanged Seams of Flue Tubes—Broad grooving of this nature (see Fig. 2) extending for a length of 18 in. where the plate was fractured through for some distance, has been successfully repaired by cutting out the defect and building up again by electric welding.

Wasting of Flanged Seams of Flue Tubes—Fig. 3 indicates the manner in which wasted tube flanges have been built up and made good by welding. After sufficient metal has been added, the surface is dressed smooth by pneumatic pitting occurs in the narrow space between the tubes where the defective part cannot be reached, and in such cases the plate has been satisfactorily built up by thickening on the fire side.

In other cases the defect has been cut out and a patch welded in, as indicated in Figs. 5 and 6. Proposals for welded patches, however, should be submitted to the chief engineer. Patches as shown in Fig. 5 are not recommended. Fig. 6 is a better arrangement, the patch being so formed that, even should the weld fail, the patch would not be blown out. Pitting and blotches of wasting on corrugated tubes may be filled in, also short fractures "Veed" out and made good, as shown in Fig. 7.

Wasting at Underlap or Overlap of Combustion Chamber of Marine Type or Cylindrical Dry-Back Boiler—In one case wasting at the bottom of furnace seam to combustion-chamber wrapper plate (Fig. 8) was built up by oxyacetylene welding. On completion all appeared satisfactory and the boiler was worked for a period of three months. On entering the combustion chamber it was found that the seam was again leaking, and on attempting to calk, the deposited

metal broke off in layers quite freely. It was decided to remove this down to the original metal and afterward to build up the parts by electric welding; this was done and a successful repair made.

Fractures Between Tube Holes of Cylindrical Dry-Back Boilers—A satisfactory repair of these defects can usually be made by welding.

Fractures in Chimney Tubes of Vertical Boilers—Such fractures are difficult of access, and probably that is the reason why, in several instances, a repair that appeared to be quite satisfactory has failed and a new chimney tube had to be fitted after spending time and money on attempting a repair in position. Apart from the difficulty of access there would be no objection to repairing such a defect as the fracture shown in Fig. 10.

Wasting in Smokebox Tube Plate of Portable Multitubular Boiler—Wasting at the bottom of the smokebox tube plate of a portable multi-tubular locomotive boiler was built up by electric welding. When welding was being done three fractures occurred between tube holes in the vicinity of the weld, as shown in Fig. 9. These fractures were also welded up and the repairs appear to have been satisfactory.

Fractures in Cast-Iron Sectional Boilers—Fractures in cast-iron boilers may be repaired by welding, and if a satisfactory repair could be assured this method would possess several advantages over replacing sections. The two examples mentioned below are typical.

1. One of the sections was fractured as indicated at *A* in Fig. 11. As a new section was not obtainable, it was decided to attempt welding by the electric process. After three attempts the repair appeared to be satisfactory and stood for a time, but later it gave out, and it was finally decided to replace the boiler rather than go to further expense in welding experiments.

2. A short fracture (see Fig. 12) occurred in one of the sections of a cast-iron hot-water circulating boiler. This was welded in position by the oxyacetylene process. The welding was apparently satisfactorily completed, but on cooling down, the section suddenly fractured with a sharp report close to the welded part, this being evidently due to contraction stresses. The section was therefore scrapped and a new one fitted. Since the time the repair was made the firm that carried out the attempt has installed a heating furnace at its works to use with this form of repair. The whole section is first put into the furnace and raised to a red heat, the casting is then withdrawn and the crack immediately welded up by the oxyacetylene process. The section is at once put back into the furnace and the fire allowed to die out. It is stated that the cost of carrying out this form of repair is about equal to a new section, but it is reported to be successful and may with advantage be adopted when new sections cannot be readily obtained.

General Note on Boiler Repairs

From the examples of repairs given it will be seen that the National company will sanction repairs to parts in compression and, within limits, to parts that may be in tension but are adequately stayed. In such cases the extent of the defect and the degree of staying will have an important bearing on the question whether a repair by welding is allowable. For instance, in a case of grooving in the front-end plate, referred to in the foregoing, short isolated grooves that are clearly distinguished and do not amount in the aggregate to any considerable length may safely be repaired, while similar grooving, where it has extended to a greater length and when the full extent is difficult to determine, must be regarded as outside the scope of such repair.

In the same way the degree in which a flat plate is stayed must be taken into consideration when defects in such parts as angle rings or flanged end plates have to be dealt with. Grooving in the flange at the circumference of a dished end is, for example, more serious than grooving in a similar position in a Lancashire boiler, because in the latter case the end plate is stayed with gussets. In either a proposal to repair grooving at the circumference of an end plate would require to be considered fully and should be submitted to the chief engineer for consideration.

Proposed Severn Barrage

A project that the *Engineer* (London) refers to as "a somewhat grandiose scheme" is the utilization of the ebb and flow of the tides in the River Severn for the production of electrical energy. Briefly stated, the proposal is to construct a dam across the river near the place where the tunnel now crosses under it, and by the employment of turbines and electric generators to provide a continuous supply of energy in excess of half a million horsepower during a ten-hour day with a peak capacity of over a million horsepower. The necessary storage feature is to be provided by using excess energy at times of maximum production to pump large volumes of water into a high-level reservoir, the power produced by this water in falling again to sea level being employed to produce current to fill up the valleys that would otherwise exist in the normal production curve. It is estimated that the potential tide-water power on the Severn with a maximum rise and fall during spring tides of about thirty feet is considerably greater than that of Niagara Falls and largely in excess of all the water power of the United Kingdom put together.

There are available four principal outlets: (a) To local manufacturing interests, for which the surrounding country is admirably adapted geographically; (b) to the industrial area of South Wales, all of which lies within a radius of 50 miles of the proposed development; (c) to the vicinity of Birmingham, which is approximately 70 miles distant, and (d) to London, 115 miles away, where the Severn power would be used to relieve the peak load of local generating installations.

The proposed development has been formulated by the Civil Engineering Department of the Ministry of Transport, the names of Sir Alexander Gibb and Messrs. J. Ferguson and T. R. Menzies being mentioned as principally responsible for the engineering and economic features involved. It seems that the Ministry of Transport is interested in the matter because of the lack of sufficient railway communication between South Wales and other parts of the kingdom and the need of access over the Severn estuary for vehicular traffic. Hence the idea of a low-level crossing to accommodate both rail and road traffic and to be used also as a dam or barrage for impounding water to be employed for the production of electric energy.

An important feature of the proposed development is a locked basin for shipping purposes over 27 square miles in extent, suitable for the accommodation of ocean-going vessels, which would be usable at all tides. A locking basin capable of taking the largest ships is to be constructed on the line of the navigable channel and intersecting the barrage, and it is proposed to lead ships into and through it by electric locomotives in a way similar to that employed in the Panama Canal. The railway and road traffic will be passed over one end or the other of the basin by means of lifting bridges, operating in such a way as to insure that there will be no delay either in railway, road or river traffic, the railway being for this purpose duplicated in the form of a loop where it crosses the locking basin.

As to the financial aspect, the *Engineer* says: "No figures are given in the official document as to the first cost of the scheme as a whole, but published guesses at it have varied between £8,000,000 and £30,000,000. It is stated, however, that the estimated cost for generation at present-day prices is a little over ½d. per Board of Trade unit. It is claimed that, incidentally, the utilization of the power derived from the operation of the scheme would effect a saving in coal consumption of from three to four million tons per year, which quantity would become available for export and would result in the amelioration of the living conditions in the great industrial areas."

The Government of the Georgian Republic has entered into an agreement with some Italian interests for the development of about 200,000,000 tons of coal which is said to be available in Georgia, according to a United States Commerce report. It should be understood, however, that the State of Georgia has not seceded from the Union; this is apparently a case of flattery by emulation.

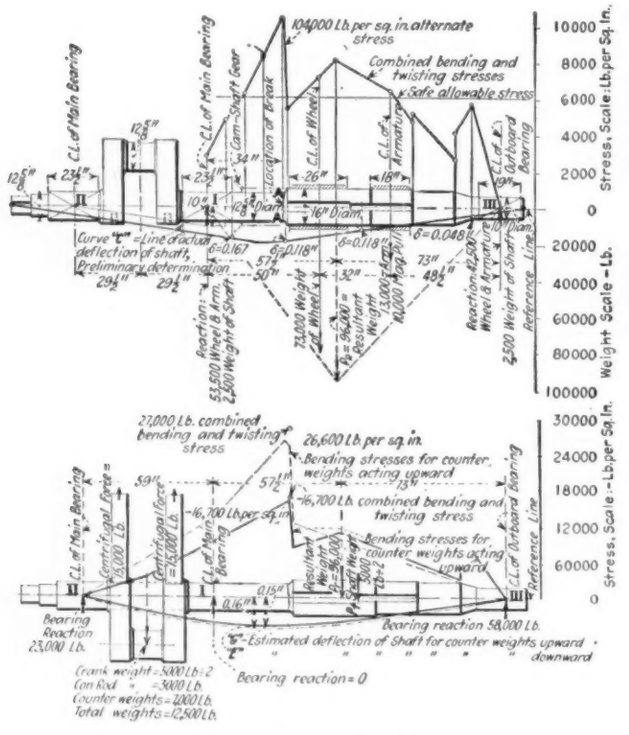
Experience with Large Center-Crankshaft*

By Louis Illmer

Several years ago a series of disastrous center-crankshaft failures occurred in a 1,200-kw. gas-power plant which the author investigated and in which he found that the wheel shafts were entirely too light for the load they had to carry.

The gas-power plant comprised three 25-in. x 43-in. 500-b.hp. double-acting producer-gas engine units, each driving a 400-kw. 25-cycle three-phase alternator at 100 r.p.m. The engines were of the direct-connected horizontal type, provided with a massive flywheel. The shafts were of the single-throw center-crank type, as indicated in the illustration, having a tensile strength of about 65,000 lb. per sq.in.

After being in 24-hour-a-day service for some four or five years, one of the shafts unexpectedly gave way near the flywheel hub, allowing the armature to drop and thus completely wreck its generator and heavy wheel, and in other ways doing serious damage.


104,000 Lb. per sq. in. alternate stress
Combined bending and twisting stresses
Safe allowable stress
Stress, Scale, Lb. per Sq. In.
Weight Scale - Lb.
Reference Line
27,000 Lb. combined bending and twisting stress
26,600 Lb. per sq. in.
Bending stresses for counter weights acting upward
16,700 Lb. combined bending and twisting stress
Bending stresses for counter weights acting upward
Bearing reaction 58,000 Lb.
Estimated deflection of Shaft for counter weights upward " downward
Bearing reaction = 0
Crank weight = 5000 Lb. x 2
Con Rod " = 3000 Lb.
Counter weights = 2000 Lb.
Total weights = 12,500 Lb.

STRESS DIAGRAMS

A series of sag determinations was conducted on the wheel shaft and a thorough technical investigation made of the underlying stress conditions.

The three-point shaft support for the heavy flywheel was found to set up a pernicious interaction of load, which led to excessive wear in the intermediate main bearing. This resulted in the lengthening of the effective shaft span, which in turn produced sag stresses of such magnitude as to cause ultimate rupture of the shaft.

The inadequacy of a center-crank shaft for carrying a heavy wheel is made evident in the accompanying deflection diagrams. An excessive wheel-shaft deflection puts a large upward thrust against the outermost main bearing cap. The reaction of this thrust upon the intermediate main bearing may become so large as to squeeze the babbitt lining out of the bearing shell, in which event the resulting drop in this vital support allows the shaft to run with an excessive sag between the outermost main bearing and the outboard bearing. Thus the shaft stresses may be increased far beyond those usually anticipated by the engine builder.

*Extract of paper read before the annual meeting of the American Society of Mechanical Engineers, Dec. 8-10, 1920.

Crankshaft Stress Diagrams

The shaft outline and load conditions under which the original shafts operated are shown in upper diagram where line *AA* indicates the location of the wheel-shaft failure, its relative position being almost identical in three of these shafts. The journal portion of the shaft was carried straight up to the wheel hub, but as indicated by the dotted outline it was entirely feasible to enlarge the shaft immediately after clearing the camshaft gear. Had this been done originally it would have obviated the worst of the peak stresses shown in the diagram.

The original shafts were excessively loaded by a massive flywheel weighing about 73,000 lb. and by an armature of about 13,000 lb., to which should be added an assumed magnetic pull of about 10,000 lb. on the basis of $\frac{1}{32}$-in. armature displacement.

In making a preliminary stress analysis in the conventional manner it may be assumed that the wheel shaft is pin-supported between the intermediate main bearing *I* and the outboard bearing *III*. The resultant wheel-shaft load P_r = 96,000 lb., acting downward, causes the shaft to deflect, thus putting the bottom fibers in tension and the top fibers in compression. The rotation of the shaft sets up a reversal of stress with each revolution.

The effect of this twisting action may best be combined with the bending moment as indicated in the stress curve. It will be seen that while the original wheel-shaft strength lacks uniformity the maximum stress estimated on this preliminary basis reaches a peak value of only about 10,000 per sq.in. near the point of rupture.

Effect of Three-Point Shaft Support

Assuming all the bearings to be in perfect alignment it will be found that the excessive wheel-shaft deflection produced by the massive flywheel puts a 20,000-lb. upward thrust against the cap of the outermost main bearing *II*, which in turn reacts upon and so overloads the intermediate bearing as to squeeze out its babbitt. The drop in this vital support causes sag stresses to be set up that more than double the peak stress previously determined by the preliminary stress check represented in the figure.

The estimated stress relations shown assume the original wheel shaft to be pin-supported between bearing *I* and *III* only, a condition that is approximated when the cap is removed from the outer main bearing *II*.

The dropping of the intermediate bearing support has the further effect of reducing the upward thrust against the bearing cap *II*, and as the downward forces undergo readjustment by continued wear, the outer main bearing *II* will gradually assume an increased portion of the downward shaft load. Experience shows that when the load upon each of the main bearings becomes approximately equal a condition of stable equilibrium will have been established, after which the two main bearings continue to wear down together at a more or less uniform rate.

The figure also shows the marked effect which the dropping of the intermediate bearing support has in enlarging the effective shaft span and thus largely increasing the bending stresses.

These high sag stresses have been checked by comparing the estimated deflection curve *E* with the actual wheel-shaft sag as taken off one of the original shafts. The deflections were determined by means of a pin gage, and these measurements were corrected for the sag of the reference cord. Thus the actual shaft sag, measured at the center of the intermediate main bearing, was found to be about 0.16 in. lower than the end supports, as against an estimated value of about 0.14 in.

The calculations show further that after reaching the aforesaid state of equilibrium the estimated maximum pressure acting in the main intermediate bearing is reduced

to about 218 lb. per sq.in. of projected area, which can readily be sustained without excessive wear. Under these conditions the shaft suffers a maximum bending stress of about 26,600 lb. per sq.in., and it is found that this peak practically coincides with the point of rupture. This extremely high stress is still further increased when combined with the crank-twisting stress.

Detrimental Effect of Heavy Counterweights

The massive counterweights with which these engines were provided were designed to balance the inertia effects of the heavy reciprocating parts, averaging about 115 lb. per sq.in. of piston area. When the centrifugal force acts upward a maximum bending stress of 16,300 lb. per sq.in. results, while for downward action the bending stress is increased to about 26,600 lb. per sq.in. Combining these high stresses with the maximum twisting stress without allowing for shock or preignition, an equivalent maximum tension stress of 27,000 lb. per sq.in. is produced in the outer shaft fiber, and when this same fiber turns through 180 deg. it is subjected to a compressive stress of about 16,700 lb. per sq.in.

No record has been kept as to the running time actually required to rupture the original shafts, but judging from the average period of operation of these engines it is probable that each of the defective shafts made between 100,000,000 and 150,000,000 revolutions prior to failure.

As based upon Stromeyer's fatigue formula, the excess stress f_{exc} required to produce rupture in the stated number of revolutions would lie between 2,700 and 3,000 lb. per sq.in. for an alternating-stress cycle. Accordingly, it would appear that the stress curves of the diagrams have been closely estimated and that the original shafts must have been subjected to a maximum tension stress approaching the elastic limit of the shaft material.

The fact that three of the original shafts became defective in practically the same place and that each shaft proved serviceable for a period approximating three years virtually precludes a defect in forging, but points rather to improper shaft design as the cause of the mishap. In fact, it now appears that the ultimate failure could have been foretold had the underlying stress relations been analyzed in the manner advocated before deciding upon the final shaft dimensions.

The Edison Medal for the year 1920 has been awarded to Dr. M. I. Pupin "for work in mathematical physics and its application to the electrical transmission of intelligence." The medal will be formally presented on Feb. 18 at a session of the midwinter convention of the American Institute of Electrical Engineers. Dr. Pupin received his early education in Europe, went through Columbia University in New York, and studied in the University of Cambridge and the University of Berlin. He helped to start the electrical-engineering department at Columbia in 1889 and has since then performed a great deal of difficult electrical and physical research work. The medal which this work has brought him is presented annually by a committee of the American Institute of Electrical Engineers "for meritorious achievement in electrical science, electrical engineering or the electrical arts." The award is made possible by the Edison Medal Association, composed of friends and associates of Thomas Edison.

A summary of all accidents and casualties on railway locomotives caused by failure of the boiler and its appurtenances for the fiscal year ended June 30, 1912, as compared with the year ended June 30, 1920, shows decreases of 47 per cent in the number of accidents, 48 per cent in the number killed and 49 per cent in the number injured. The annual report of the government inspector of locomotives is authority for these figures and points out that these decreases in accidents were brought about in spite of increases in the number of locomotives in service, and that they are consequently strong testimonials to the value of the locomotive boiler-inspection law, which was passed about eight years ago.

Power Costs, 1914-19

A recent number of the *Sibley Journal* contained an article on Power Costs, 1914-19 by Hubert E. Collins, in which appeared comparative data applying to a number of power plants between the years indicated. One of these, situated in the Mohawk Valley, New York State, gives records quite complete in detail, which are reproduced herewith. The fuel used was anthracite dust and bituminous mixed in equal proportions for the years 1914 to 1916 inclusive and bituminous only in 1917 and 1918. Induced draft was used in 1914 and 1915 and natural draft in 1916-18. Fuel costs were based on long tons delivered to siding.

TABLE I. COMPARISON OF POWER PLANT PERFORMANCES

	1914	1915	1916	1917	1918
Tons coal used	9,208	9,171	11,164	12,469	12,739
Cost of coal	$26,045	$21,333	$31,894	$37,533	$40,786
Pounds coal	20,655,920	20,544,160	25,007,360	27,932,128	28,536,928
Pounds steam production	181,772,096	169,136,636	195,256,860	204,189,600	206,106,150
Kw. hr. production	1,561,318	1,623,153	2,036,567	1,981,370	1,970,970
B.hp. production	6,059,066	5,717,520	6,508,562	6,806,320	6,870,205
Working days	277	292	292	292	297
Heating hours	3,080	3,024	3,182	3,361	3,423
Average evaporation	8.8	8.5	7.8	7.3	7.2
Water per kw. hr.	21.9	28.0	22.0	22.8	22.8
Coal per kw.-hr.	2.49	3.3	2.8	3.1	3.1
Coal per b.-hp.	3.4	3.5	3.8	4.1	4.2
Cost of coal per pound	0.00126	0.00105	0.00128	0.00134	0.00143
Cost of coal per b.-hp.	0.0042	0.0037	0.0048	0.0055	0.006
Cost of coal per kw.-hr.	0.00313	0.0035	0.00358	0.0045	0.00443

TABLE II. AVERAGE COST PER KILOWATT HOUR

	1914	1915	1916	1917	1918
Wages	$0.00159	$0.00147	$0.00147	$0.00168	$0.00198
Water	.000131	.000168	.00013	.000137	.000189
Fuel	.00313	.0035	.00358	.0045	.00443
Dep. on building	.00127	.00123	.00098	.001	.001
Dep. on machinery	.00338	.00325	.0026	.00267	.00267
Total cost	$0.009501	$0.009618	$0.00876	$0.009987	$0.010269

Senator Calder's Plan*

"Our investigation into the coal situation has convinced me that the private interests now in control of the production and distribution of coal, in spite of efforts by some, are actually unable to prevent a continuance or a repetition of the present deplorable situation, and that it is the duty of the government to take such reasonable and practical steps as it may to remedy the evil.

"The committee has felt disposed before it actually urges the establishment of complete government control, or even the licensing system, to recommend that all coal operators, wholesalers, jobbers and retailers be compelled by statute to file at regular and frequent periods with some Federal agency reports on the total tonnage produced or handled, the size and quality thereof, the amount of tonnage contracted for, the amount sold on contract and at spot sale, to whom, together with the prices made or received under such contracts or sales.

"Mr. President, we are not sure that the remedy proposed will be adequate, but believe it should be tried before the government goes into business itself. It would afford opportunity for the public to know the exact cost of production, the price coal was sold for and to whom. It would also afford opportunity for coal to be traced to its final destination and in all probability would bring the relief desired. The committee makes this recommendation now and is to inquire further into the situation."

Eels Block Water Wheel

Plymouth, Mass., Dec. 18.—Eels, hundreds of them, crawled into the waterwheel that furnished power for the Cobb & Drew factory at Rocky Nook and compelled closing the mill. Records show that it was just fifty years ago that a like thing happened at the old mill.—*New York Sun.*

If it isn't one thing it's another. Tell your troubleman to look out for eels.

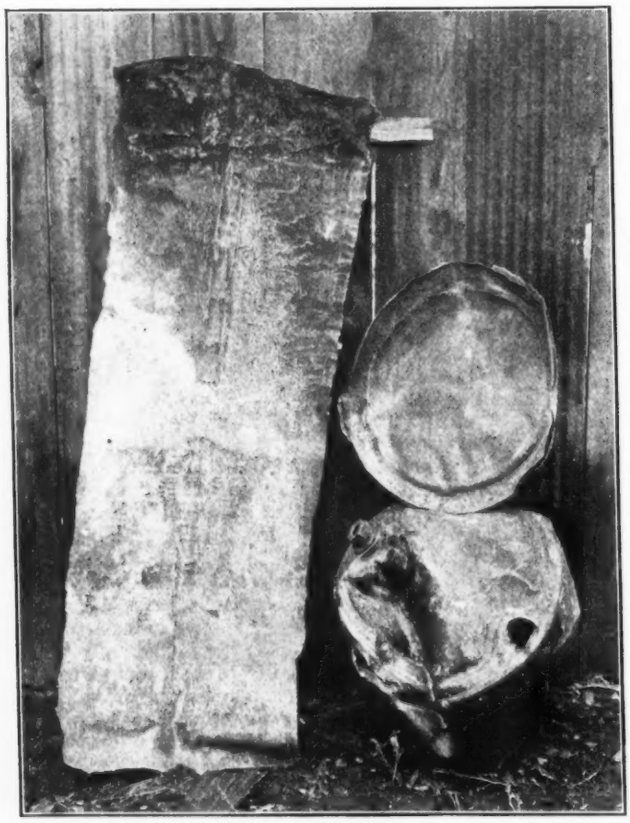
*Excerpts from Senator Calder's remarks in the Senate on Dec. 23 on the investigation into the coal situation being made by his committee.

Hot-Water Tank Explosion

By J. P. Morrison

Shortly after 9 o'clock Friday morning, Dec. 10, considerable damage was done to property and the lives of a number of persons were endangered by the explosion of a hot-water receiving tank at the plant of the H. J. Lindsay laundry, at Appleton, Wis. The hot-water tank was originally an iron oil barrel, having a volume of 50 or 55 gal., such as is used by oil companies to ship kerosene and gasoline to small distributors. After the explosion the iron shell plate measured only 0.0409 in. in thickness.

In the one-story laundry building the tank had been placed about ten feet above the floor. It received the water of condensation from the dry-room coil. A 1-in. live-steam line connected the tank to the small horizontal-tubular boiler, so that the temperature of the water in the tank could be increased when desired. The tank was equipped with an open vent pipe ¾-in. in diameter, which



HOW THE OIL BARREL LOOKED AFTER THE EXPLOSION

was intended to prevent any pressure accumulating within. The boiler was in operation under a pressure of 80 lb. on the morning of the accident, when the steam valve in the pipe line leading to the receiving tank was opened. Of course with a 1-in. diameter inlet and only a ¾-in. vent pipe, the pressure in the tank would soon equal that in the boiler. That the strength of the metal of the tank was not sufficient to sustain the pressure is indicated by the accompanying illustration.

There are undoubtedly a great many water and air tanks not intended for use as pressure-carrying vessels, so connected that an error in manipulation of the valves may produce a dangerous condition. A good principle to follow in connecting up vessels of that description, where they are not to be operated under pressure, is to provide a clear opening to the atmosphere, having a cross-sectional area at least twice the size of the intake pipe, and if a tank intended for water or air storage, or a blowoff connection, is so designed and constructed that it will be capable of safely withstanding the maximum pressure to which it could be subjected with the vent pipes closed, there would be fewer failures of that class of equipment.

Hydro-Electric Symposium To Be Held in Philadelphia

A symposium on Hydro-Electric Power and Distribution will be held under the auspices of the Engineers' Club of Philadelphia and the Philadelphia Sections of the American Society of Civil Engineers, the American Institute of Electrical Engineers and the American Society of Mechanical Engineers on Friday, Jan. 21. Technical session at 2:45 p.m. and general session at 8 p.m. will be held in the Auditorium of the Manufacturers' Club. Informal Dinner at 6:30 p.m. at the Bellevue-Stratford Hotel. Dinner tickets ($2.50) can be obtained at the Engineers' Club.

The program of the meeting includes: "The Modern Hydraulic Turbine" (illustrated), by Frank H. Rogers, Hydraulic Engineer, I. P. Morris Dept., the William Cramp & Sons Ship and Engine Building Co.; The Application of a New Method of Water Measurement in the Efficiency Tests of the 37,500-Hp. Turbines of the Niagara Falls Power Company" (illustrated), by Norman R. Gibson, Hydraulic Engineer, the Niagara Falls Power Co., Niagara Falls, N. Y.; "Surges in Conduits and Other Hydraulic Problems" (illustrated), by Raymond D. Johnson, Consulting Engineer, New York City; "The Present Trend of Hydraulic Turbine Development" (illustrated), by Lewis F. Moody, Consulting Engineer, I. P. Morris Dept., the William Cramp & Sons Ship and Engine Building Co.; "Niagara Falls Power Development and Its Products in Philadelphia" (illustrated), by John L. Harper, Vice-President and Chief Engineer, the Niagara Falls Power Company, Niagara Falls, N. Y.; "Electrical Features of Hydro-Electric Power" (illustrated), by David B. Rushmore, Chief Engineer, Power and Mining Department, General Electric Co., Schenectady, N. Y.

H. Foster Bain New Director of Bureau of Mines

H. Foster Bain is to be the new head of the Bureau of Mines, in place of Dr. F. G. Cottrell, who recently resigned to take charge of the division of chemistry and chemical technology of the National Research Council. Mr. Bain is already thoroughly familiar with his new duties, because he was assistant director of the Bureau during part of the war. He followed up production and manufacture of metal products, explosives and chemical substances necessary in the prosecution of the war, returning to private life, however, at the conclusion of hostilities.

Mr. Bain's birthplace was Seymour, Indiana. He was graduated from Moore's Hill College, Indiana, in 1890, then studied at Johns Hopkins University for two years and finally was given his doctor's degree by the University of Chicago.

He has devoted his life to geology and mining engineering. He was the editor of the *Mining and Scientific Press*, of San Francisco, and later of the *Mining Magazine*, of London. Subsequently, he was one of Herbert Hoover's London assistants in carrying on Belgian relief work.

Mr. Bain's mining experience has been varied in the extreme. He started as a shift boss in a mine, later taking charge of the Franklin gold-silver mine in Colorado. He has done consulting work in the Rand, the Belgian Congo, and other mining regions of Africa and the Far East. He recently concluded a trip on which he conducted mining examinations in ten Oriental countries.

For a time Mr. Bain was with the United States Geological Survey, and was the first director of the Geological Survey of Illinois. He has been prominent in the American Mining Congress, the American Institute of Mining and Metallurgical Engineers and the Mining and Metallurgical Society of America.

New Publications

EXPORT REGISTER OF THE FEDERATION OF BRITISH INDUSTRIES. Published by the Industrial Publicity Service, Ltd., 4-7 Red Lion Court, London, E. C. 4. Cloth, 7 x 10 in.; 640 pages.

This book is a trade directory of British firms and trade associations. It is not complete, but it is claimed that the most important firms are represented. About 300 pages are devoted to advertisements, and the remainder is taken up with two lists of firms and individuals, one arranged alphabetically by name and the other classified according to product.

COMPRESSED AIR PLANT. By Robert Peele. Published by John Wiley & Sons, Inc., New York. Cloth, 6 x 9 in.; 506 pages; 254 illustrations. Price, $4.50.

This is the fourth edition of a work that first appeared in 1908, and deals with the production, transmission and use of compressed air, with special reference to mine service. The first half of the book takes up the structure and operation of various kinds of compressors, the theory of air compression, wet and dry compressors, compound compressors, valves, valve motion, etc. The other half describes the methods of transmission and use of compressed air, including piping, compressed-air engines, freezing of moisture, reheating air, rock drills, hammer drills, coal cutting machinery, channeling machines, compressed-air mine pumps, and mine haulage by compressed air. The present volume includes a new chapter on measurements of air consumption, comprising data on the flow of air to orifices in short tubes, and a discussion of different appliances for measuring air, both high- and low-pressure, including simple plant apparatus that can be readily improvised. A note has also been appended to Chapter 25 of the preceding issue, relative to some important air-lift work recently done at a large mine in Mexico.

Personals

Major James R. Werth is now commercial service manager of the West Penn Power Co., with offices at 14 Wood St., Pittsburgh.

Fred Felderman has been elected chairman of the 1921 New York State convention committee of the National Association of Stationary Engineers.

W. R. Harvey, who has been a Chicago representative of the *Literary Digest* for the past five years, is now Western advertising manager of *Industrial Power*, Chicago.

Dr. F. G. Cottrell has resigned his position as director of the Bureau of Mines to take up his new work as chairman of the Division of Chemistry and Chemical Technology of the National Research Council.

R. F. Hyward has given up his position as general manager of the Western Canada Power Co., Ltd., of Vancouver, and is now general manager of the Chilian Electric Tramway and Light Co., Ltd., Santiago, Chile.

Society Affairs

Chicago Section, A. I. S. E. E., will meet Jan. 15 to hear a talk on "Efficient Electric Power Generation," by A. T. Clark, of the firm of Sargent & Lundy.

Boston Section, A. S. M. E., will hold a joint meeting with Boston Section A. I. E. E., on Jan. 18. W. S. Murray will speak on the Superpower System.

Pittsfield Section, A. I. E. E., will meet Jan. 20 to hear an address by B. R. Baumgardt entitled "On the Frontiers of the Universe, or "An Evening with the Stars."

Pittsburgh Section, Association of Iron and Steel Electrical Engineers, will meet Jan. 15 to hear L. F. Galbreath, of the West Penn Steel Co., discuss "Relative Depreciation of Machinery."

The National Marine Engineers Beneficial Association will hold its forty-sixth annual convention at Washington, D. C., during the week of January 16-21, with headquarters at the New Ebbetts Hotel.

Philadelphia Section, A. I. E. E., A. S. C. E. and A. S. M. E., and the Engineers' Club of Philadelphia are to hold a symposium on Hydro-Electric Power and Distribution Jan. 21. The program appears elsewhere in this issue.

The New England Water Works Association will hold its annual meeting on Jan. 12 at Copley Square Hotel, Boston. During the afternoon several committees will present their reports, among which will be one on "Pumping Station Records."

The National Association of Stationary Engineers will hold the annual ball of the combined associations of Manhattan, Bronx and Queens boroughs of New York at 8:30 p.m., Jan. 15, at Palm Garden, 58th St. near Lexington Ave., New York City. Out-of-town members will be welcome.

The American Institute of Electrical Engineers will hold its 366th meeting at Akron and Cleveland on Jan. 14. Business affairs will be handled in the morning at Akron, and in the afternoon a trip will be made through the B. F. Goodrich Plant. An informal dinner will be held at 6:30 p.m. at the Hotel Statler, Cleveland, and at 8:15, at the technical session, a paper on "Application of Electric Power in the Rubber Industry" will be read.

Pennsylvania Section, Society of Automotive Engineers, will meet in Philadelphia Jan. 18. In the afternoon a trip will be made to the Philadelphia Navy Yard to inspect a Diesel engine and in the evening an address, "Petroleum from Well to Finished Product," will be given at the Engineers' Club.

The Iowa Engineering Society will hold its annual meeting at the Chamberlain Hotel, Des Moines, Iowa, Jan. 18-20. Manufacturers' exhibits have been arranged to be of interest to the public as well as to engineers. Preparations for the entertainment of ladies have been made, and all registered engineers, whether members or not, are invited.

Business Items

The Mesta Machine Co., of Pittsburgh, Pa., has opened a branch office at Chicago, Ill. The office is temporarily in the Railway Exchange Building, but will be moved to permanent quarters in the McCormick Building after April 1. The Chicago office will be in charge of C. J. Mesta, second vice president of the company.

The Fisher Governor Co., of Marshalltown, Iowa, is now manufacturing the O-B Regulating Valve, which will be known as Fisher Pressure Regulating Valve, Type 90. It is claimed that this valve maintains a predetermined low pressure on the service side, and automatically shuts off tight when no pressure is required. It was formerly made by the Ohio Brass Co., of Mansfield, Ohio.

Trade Catalogs

The National Airoil Burner Co., 9th and Thompson Sts., Philadelphia, is distributing a 9 x 3½-in., 18-page folder setting forth the advantages of its internal steam atomizing oil burners.

The Ross Heater and Manufacturing Co., Inc., has put out a 6 x 9-in., 40-page catalog of condensers, evaporators and instantaneous and storage heaters of the closed or tubular type for heating any kind of fluid with steam.

The McAlear Manufacturing Co., Chicago, Ill., has issued three bulletins, C, D and E, 6 x 9-in., totaling 32 pages, descriptive of its line of vacuum air-line heating systems; packless radiator valves; and high- and low-pressure steam traps and thermo-vent air valves.

COAL PRICES

Current mine quotations, with interesting comparisons, are given in the following tabulation:

	Nov. 1919*	Aug. 5 1920	Dec. 16 1920	Jan. 6 1921
Pittsburgh steam	$2.30	$10.00	$3.25	$2.60
Pittsburgh screened gas	2.30	12.00	3.75	3.15
Hocking	2.50	9.00	3.00	2.50
Franklin, Ill	2.35	6.50	3.40	3.00
Indiana 4th vein	2.35	7.50	3.25	2.75
Eastern Ohio, No. 8	2.35	10.50	3.40	2.75
Fairmont	2.50	13.50	3.00	2.40
Kanawha	2.60	14.00	3.50	2.80
S. E. Kentucky	3.00	10.50	4.00	2.90
Western Kentucky	2.35	5.25	3.75	2.60
Clearfield	2.95	12.00	3.75	3.25
Cambria and Somerset	2.95	13.50	4.75	4.35
New River	2.70	14.00	5.00	4.50
Pocahontas	2.35			

*Government prices.

New Construction

PROPOSED WORK

Mass., Boston—The Kneeland St. Garage, Inc., c/o J. C. Spofford, Archt., 36 Broomfield St., is having plans revised for a 9 story, 30 x 195 ft. garage building. About $800,000.

Mass., Boston—The Schoolhouse Dept. is having plans prepared for a 2 story school on Walnut Ave. About $250,000. J. H. Ritchie, 15 Ashburton Place, Archt.

Mass., Boston—The Mass. Ave. Station Garage will receive bids Jan. 15 for a 5 story garage building on Massachusetts Ave. About $800,000. J. C. Spofford, 36 Bromfield St., Archt.

Mass., Roxbury (Boston P. O.)—The Schoolhouse Dept., City Hall, Boston, plans to build a 2 story grade school in the George Putnam District here. About $360,000. J. J. Driscoll, 6 Beacon St., Boston, Archt.

Mass., Wakefield—The city voted to appropriate $25,000 for rebuilding the municipal light plant.

Conn., Hartford—The Hartford Hospital, 20 Hudson St., is having plans prepared for 6 story hospital. About $500,000. C. J. Malmfeldt, Professional Bldg., Archt.

N. Y., Brooklyn—S. Brill, 103 West 46th St., New York City, is having plans prepared for a theater including a steam heating system on Manhattan St., here. About $400,000. E. DeRosa, 110 West 40th St., New York City, Engr.

N. Y., Cortland—The Valeria Home, 7 East 42d St., New York City, had sketches prepared for an institution, here. About $1,000,000. Chas. Higgins, 19 West 44th St. and Delano & Aldrich, 126 East 38th St., both of New York City, Archts.

N. Y., New York—The Board of Purchases received bids for furnishing and delivering boilers, condenser tubes, etc., from Amer. Brass Co., 195 Bway., $6,944; Kearfoot Engr. Co., $7,117.60; E. F. Keating, 446 Water St., $7,863.

N. Y., New York—The Seaman's Church Inst., c/o Warren & Wetmore, Archts., 10 East 47th St., plans to build an 11 story, 100 x 125 ft. institute including a steam heating system at 41 Front St.

N. Y., New York—The Manhattan College, 131st St. and Bway., plans to build several college buildings. About $1,000,000. Architect not selected.

N. Y., Schenectady—Max Spiegel, 1579 Bway., New York City, is having plans prepared for a theater, here, including a steam heating system. About $500,000. Reilly & Hall, 405 Lexington Ave., New York City, Archts. and Engrs.

N. J., Newark—The Bd. Educ., City Hall, has accepted plans for a 3 story, 165 x 205 ft. grammar school on Grove Ave. About $800,000. J. B. Allen, 1091 Sanford Ave., Archt.

N. J., Wharton—J. Kernick, Borough Clk., will receive bids until Jan. 31 for improvements to the water supply system including the construction of a pumping station, etc. A. Potter, 50 Church St., New York City, Consulting Engr.

Pa., Ambridge—The Columbia Steel Shafting Co., Park Bldg., Pittsburgh, is

having preliminary plans prepared for a 1 and 2 story, 600 x 600 ft. factory here. About $1,000,000. C. C. Hoon, 1505 Park Bldg., Pittsburgh, Engr.

Pa., McKeesport — Rowland & Clarke, Jenkin's Arcade, Pittsburgh, are having preliminary plans prepared for a 2 story moving picture theater at 5th Ave. and Jerome St., here. About $250,000. H. S. Blair, Vandergrift Bldg., Pittsburgh, Archt.

Pa., Pittsburgh—The Bell Telephone Co. of Pa., 416 7th Ave., will soon award the contract for a 2 and 3 story, 61 x 126 ft. and 51 x 62 ft. telephone exchange building at North Highland Ave. and Rural St. About $300,000. J. T. Windrim, Commonwealth Bldg., Philadelphia, Archt.

Pa., Woodlawn—The Beaver Bldg. Block Co., Box 832, is in the market for one 2-hp. two 5 hp. and one 10 hp. motors, also a 48 ft. movable belt conveyor and an 8 ft. stationary belt conveyor. B. R. Garrett, Vice-Pres.

Md., Baltimore—The Duraflex Co., 409 Continental Bldg., is in the market for one 20 to 25 hp. vertical boiler (used).

W. Va., South Charleston—The Bureau of Yards and Docks, Navy Dept., Washington, D. C., received bid for sub-station switchboards at the Naval Ordnance Plant, here, from the Westinghouse Electric & Mfg. Co., Hibbs Bldg., Washington, D. C., at $47,435, 120 days.

N. C., Greenville—The city plans to expend $65,000 for improvements to water and light plant including installation of turbines, boilers, etc. A. H. Taft, Town Treasurer.

Ga., Atlanta—C. F. Palmer will soon award the contract for a 4 story office building including a steam heating plant at Marietta and Forsyth Sts. About $250,000. Burge, Steven & Conklin, Atlanta Trust Bldg., Archts.

O., Cleveland—The City Ice Delivery Co., H. D. Norval, Mgr., Cadillac Bldg., is receiving bids for a 1 story, 65 x 140 ft. ice manufacturing and storage plant on Saranac Rd. About $75,000. C. C. Coneby, Cadillac Bldg., Archt. and Engr.

O., Cleveland—The Franklin Apartments Co., c/o A. W. Harris, Archt., Schofield Bldg., is having plans prepared for a 113 x 137 ft. apartment building including a steam heating system in Franklin Circle. About $400,000.

O., Cleveland—B. Lederman, 10709 Pasedena Ave., is having plans prepared for a 6 story, 60 x 255 ft. apartment hotel including a steam heating system at 2026 East 107th St. About $500,000. M. Weis, 618 Union Bldg., Archt.

O., Columbus—The Board of Trustees of the Ohio State University has asked for an appropriation of $4,000,000 for the construction of thirteen buildings. Plans include a new unit for the power plant to cost $284,000, and a wireless laboratory. About $40,000.

O., Salem—The city plans to build a pumping station, filtration plant, etc. About $800,000. B. M. French, City Engr.

Ind., Frankfort — The City Council authorized a $175,000 bond issue for a light plant.

Ind., Indianapolis—J. E. Wild & Co., 123 East Market St., plans to build a 12 story bank building including a steam heating plant. About $1,000,000. F. S. Cannon, 21 Virginia Ave., Archt.

Ind., Indianapolis — The Independent Athletic Club, Pratt and Meridian Sts., plans to build a 9 story addition to athletic club including a steam heating system on North Meridian St. About $300,000. Adolph Scherrer, Indianapolis, Archt.

Ind., Marion—The First Natl. Bank is receiving bids for a 1 story, 100 x 150 ft. bank including a steam heating plant. About $300,000. Vonnegut, Bohn & Mueller, 610 Ind. Trust Bldg., Indianapolis, Archts.

Ind., Winchester — The Bd. of County Comrs. plans to build a 2 story, 165 x 165 ft. memorial building. About $400,000. Architect and Engineer not selected.

Mich., Detroit—The Dept. of Pub. Welfare, City Service Bldg., received lowest bid for public market on Russell St., from W. E. Wood Co., 1805 Ford Bldg., $220,000. A steam heating system will be installed in same.

Mich., Detroit—The Bd. Educ., 50 Bway. Ave., is having plans prepared for a 2 story school including a plenum steam heating system, on Waterman Ave. and Fort St. About $750,000. Malcomson, Higginbotham & Palmer, 405 Moffat Bldg., Archts., Ammerman & McColl, Penobscot Bldg., Engrs.

Mich., Jackson — The Michigan States Prison plans to build 2 and 3 story prison buildings. About $5,000,000. H. L. Hulburt, Warden.

Mich. Otsego — The MacSim-Bar Paper Co. plans to build a power plant. About $50,000. B. M. Baxter, 5716 Euclid Ave., Cleveland, O., Engr.

Wis., Darlington—J. G. Swift, City Clk., will receive bids until Jan. 14 for furnishing one single stage, volute type, horizontally split case centrifugal pump to be motor driven. W. Reichardt, Watertown, Engr.

Wis., Milwaukee — The Amer. Luther League, 11th and State Sts., had preliminary plans prepared for a 4 story clubhouse. About $400,000. E. Weyland, Caswell Blk., Archt.

Iowa, Manchester—The city plans to improve waterworks and install boilers in the light plant.

Minn., Duluth—The Duluth Edison Electric Co., 216 West 1st St., will award contract about Jan. 15 for a 30 x 57 ft., 2,000-kw. transformer station. Contract for equipment has been awarded to the American General Electric Co. Total estimate cost $165,000.

Minn., Northfield—St. Olaf's College plans to build a 3 story, 73 x 186 ft. science hall to cost about $300,000 and a dormitory and heating plant, about $200,000. N. E. Mohn, 596 Endicott Bldg., St. Paul, Archt.

Minn., St. Paul—The Sears-Roebuck Co., Arthington St. and Homan Ave., plans to build a mail-order building, here. About $1,000,000. Architect not announced.

N. D., Bismarck—The city will readvertise for new bids for water works system including pumping station, filtration plant, reservoirs, etc. About $1,300,000. Former bids rejected. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Minn., Engr. Noted June 29.

Kan., Liberal—L. V. Gardner and associates are having plans prepared for a 5 story hotel. About $250,000. W. G. Charles & Co., 601 Schwerter Bldg., Wichita, Archt.

Neb., Minatare—The city plans to install 2 centrifugal pumps, gas engines, electric motors, etc., in connection with the sewage system. About $40,292. R. O. Chambers, City Clk.

Mo., Springfield—The Aboli Ben Adem Shrine is having plans prepared for a 3 story, 140 x 200 ft. temple including a steam heating system. About $300,000. Heckenlively & Mark, Landers Bldg., Archt.

Okla., Hugoton—The city plans an election April 5 to vote on a $100,000 bond issue for the construction of an electric light and water plant.

Tex., Childress—The Fort Worth & Denver City Railroad Co., F. E. Clarity, Vice-Pres. and Gen. Mgr., Denver Record Bldg., Fort Worth, is having plans prepared for the erection of a power plant, boiler house, extension to yards, etc., here. About $500,000. R. C. Gowdy, Denver, Col., Chief Engr.

Tex., Fort Worth—The Fort Worth & Denver City Railroad Co. is having plans prepared for enlargement of power house, erection of boiler house, replacing present turntable with a 90-ft. turntable, etc. About $150,000. R. C. Gowdy, Denver, Col., Chief Engr.

Cal., Los Angeles—The Hill St. Fireproof Bldg. Co. had plans prepared for a 7 story theater and office building including a steam heating system. About $1,000,000. E. Bergstrom, 1129 Citizens' Bank Bldg., Archt.

Ont., East London (London P. O.)—The Public Utilities Comn., Hydro Bldg., London, plans to build a sub-station here. Transformers and other equipment will be required. About $35,000. E. V. Buchanan, Hydro Bldg., London, Engr.

Ont., Frankford—The Canada Boxboard Co., Seigneurs St., Montreal, will receive bids in February for the construction of a ground-wood plant here. About $300,000.

CONTRACTS AWARDED

N. Y., New York—The Dept. of Pub. Welfare, Municipal Bldg., has awarded the contract for a refrigerating plant at Blackwell's Island to G. E. Ward, 47 East 34th St., at $33,875. Noted Dec. 21.

Pa., Philadelphia — St. Agnes' Hospital, Broad and Mifflin Sts., has awarded the contract for a 5 story, 84 x 161 ft. nurses' home including a steam heating system to M. Melody & Son, 1322 Race St. Noted Nov. 23.

N. C., Kinston—The city has awarded the contract for a municipal power plant building and pumping station to R. L. Blalock, Kinston, $78,000. Noted Dec. 7.

Cal., Los Angeles—The Union Ice Co. has awarded the contract for a 1 story, 48 x 100 ft. addition to ice plant at 1801 Mesa St. to C. M. Gray & Son, 2650 Santa Fe St., at $65,000. Compressor and ice tank will be installed in same.

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